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Fifth Annual Field Conference



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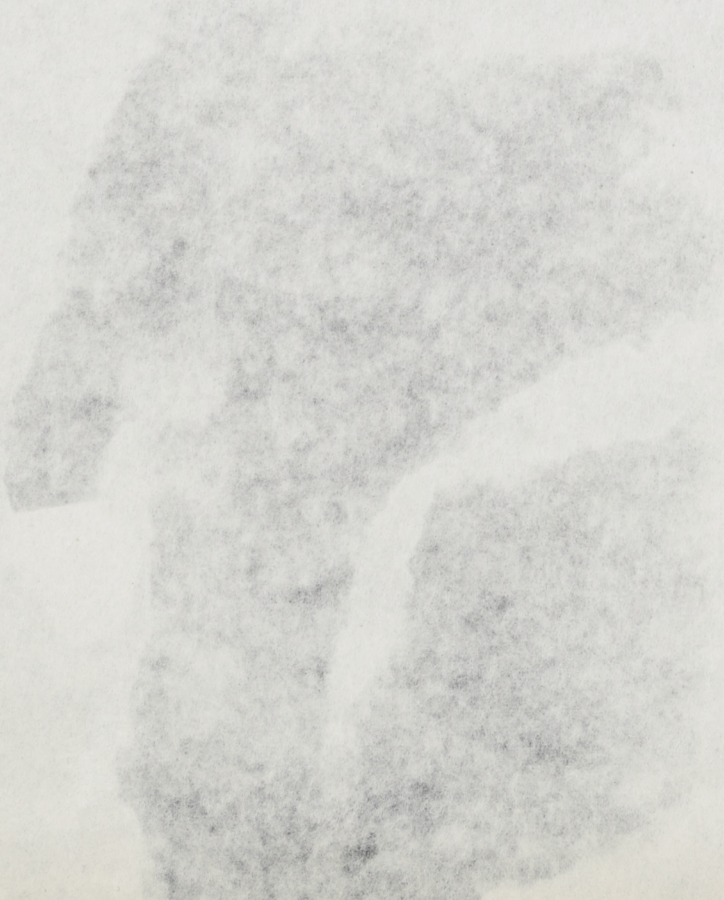
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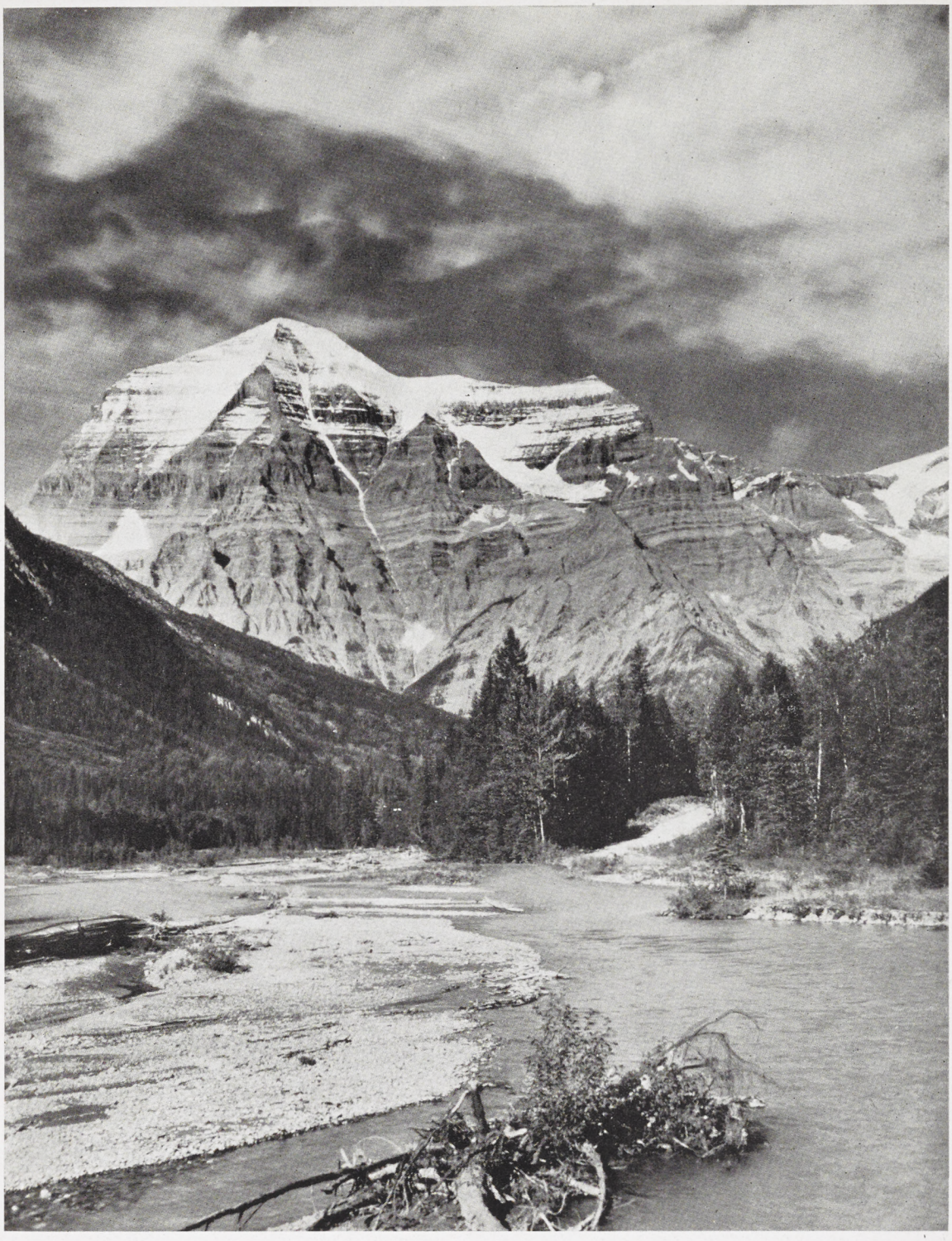
Fifth Annual

Field Conference

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JASPER NATIONAL PARK

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Frontispiece

Mount Robson, 12,972 feet—from Grand Forks River. Highest mountain in the Canadian Rockies. Altitude from which picture was taken, 2,900 feet. 10,000 feet of mostly Cambrian sediments exposed. Autumn view shows minimum amount of snow. Shoulder on left is Little Grizzly (Cinnamon) Mountain, whose Proterozoic "Miette" clastics plunge underneath Robson.

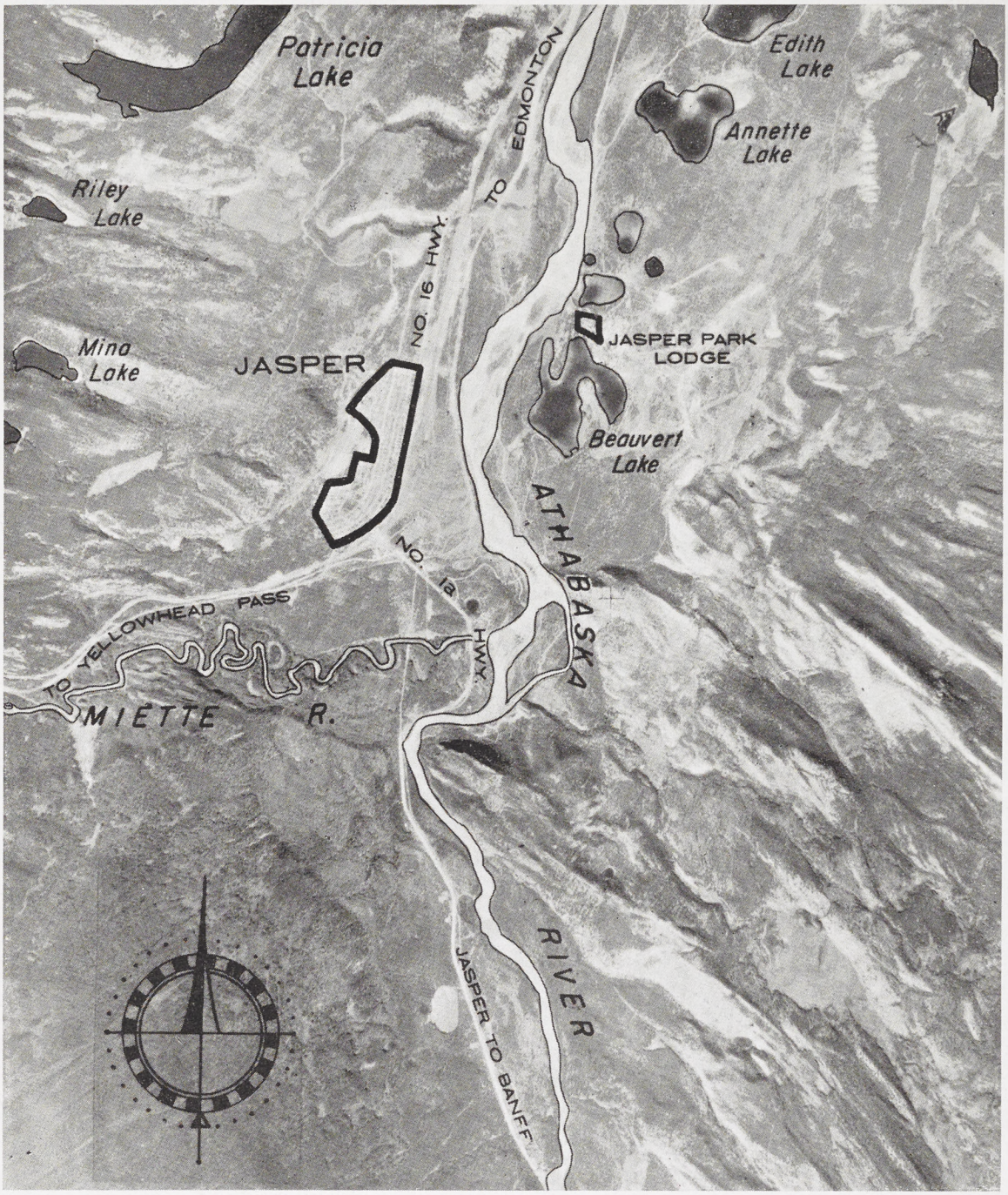


Photo by courtesy of Alberta Government Dept. of Lands and Forests.

Through the courtesy of Geophoto Services Ltd. we have an annotated vertical air photograph of Jasper Town and vicinity. We hope that it may help the first time visitors with the usual problems of getting directions settled.

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Similarly we are unable to express by individual names, thanks to many service companies who have and will have rendered many courtesies and much substantial aid in making the conference and field trip a social success. Nevertheless we must express thanks and appreciation in a general way at this time.

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The following is a list of firms and individuals who have advertised in the Field Guide Book:—

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Through the courtesy of the Geological Survey of Canada we were able to obtain a number of pictures which, in addition to their interest from the point of photographic history, have been helpful to us in setting a theme for our field trip through the Jasper National Park. This particular picture is from a photo by Horetsky, who visited the area several years after Sir James Hector, which would be about 1860.

When one considers that no dry plates, or roll film were available in those days, the transportation of cumbersome wet plate processing equipment must be regarded as a substantial feat, since no highways or railroads as we know them existed at the time.

We have taken the liberty of moving the "Davy Crockett" figures to better fit the format of our cover, and through an oversight have omitted the Bighorn Sheep head visible in the above picture of the original. However in every other respect the cover picture is authentic.

PREFACE

The decision of the Alberta Society to conduct its fifth Annual Field Trip in conjunction with the A. A. P. G. regional conference at Jasper, has provided another and excellent opportunity for the preparation of a field guide book. Because this area is accessible and replete with first class rock outcrops of sediments which range in age from late Pre-Cambrian to Recent, it is believed a review of its geology will provide a useful background for the better understanding of our whole Great Plains region.

While the editors feel that the various papers which compose this book will provide some new material for the advanced student of the area, a good deal of thought has been given to the arrangement and presentation of primary material. This has been done with the hope that the end result might be truly a guide book to those of our group, possibly the majority, who have not had the good fortune nor the opportunity to carry out first hand studies.

It is possible that the advanced geologist may at times forget his duties to the novice geologist. Though our literature is relatively small compared to older countries, it has been increasing rapidly, and its mastery by the new geologist is becoming a more formidable task than was the case a score of years ago. The editors have attempted by arrangement to help in this regard. In the leading paper by Mr. Hargreaves, an attempt has been made to create a framework of time and space. It will be apparent to the readers that the following authors have done a commendable job of sustaining the setting.

In addition to serving those of our profession it is hoped also that this volume may be of some assistance and inspiration to the layman. Like us he will on the first visit to the area, be filled with awe by the majestic scenes around him and will wonder about the events and conditions which produced them. It is generally difficult for the professional geologist to write in a fashion which is suitable to his purposes and which is at the same time comprehensible to the layman, but it is hoped that the inclusion of many photographs with explanatory captions, as well as diagrams and maps will compensate to some extent for this lengthy unavoidable failing.

It should be recorded that the papers published in this volume were contributed by authors already heavily burdened by their regular duties. The many hours spent in field checking and at other tasks, while lovingly done, were done at considerable sacrifice. Considering the relatively short time available for preparation it is amazing that the papers were submitted so promptly. Knowing these things the editors are compelled to express their admiration and gratitude, and on behalf of the whole Society their thanks.

THE EDITORS.

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THE ATHABASCA TRAIL

G. E. HARGREAVES*

Approximately 4200 square miles of rugged, mountainous, terrain known as Jasper National Park, extends northwards from the unique Columbia Icefields, to the seldom seen headwaters of the Smoky River. It is bounded by the foothills to the east, and the Continental Divide to the west. Draining this largest of Canada's National Parks, is the Athabasca River, the broad, open valley of which was well known long ago by the Indians who hunted along its banks, and travelled its fast-flowing course homewards to their Shuswap Nation. These dwellers of the Athabasca valley knew a choice of routes along which they could return with their brides — the high Athabasca Pass near the southern limits of the Park, or the easy, longer route of the Yellowhead Pass. Both these passes on the western side of the Park served the Indians well, because both led down to the easily traversed Athabasca River, or Mistahay Shakow Seepee "The Great River of the Woods," which was navigable by canoe or raft out onto the plains.

The Athabasca Pass, at the head of the Whirlpool River (see map), was a more direct means of communication with the southern interior of British Columbia since it led down the Wood River to the great northward bend in the Columbia River, and it was through this pass that the first white men to see the Jasper area travelled. The snow-filled summit however, at an elevation of 5724′, was a great deterrent.

The Yellowhead Pass, near the head of the Miette River, although much lower, left the westward-bound traveller with the choice of continuing down over the rapids of the Fraser, or crossing the unknown North Thompson River route, or proceeding round-about down the Canoe River to the Columbia. Thus, the Yellowhead Pass was slow to come into favour with the white men who first searched for a Northwest Passage, but today it serves as one of the main portals of trans-continental flow.

THE FIRST WHITE MEN

Jasper Hawes, a big, fair-haired trapper and Factor for the Northwest Company, now more legend than anything else, was the first white man on record to see the Jasper area. His establishment of the Jasper House trading post in 1801 opened the way to trade in furs and further exploration. Located originally near the mouth of Solomon Creek at the north end of Brule Lake on the Athabasca River, this post through the years to 1884 was host to many a passing adventurer, trapper, or missionary. In its early years, Jasper Hawes and his Indian wife became known for the well-cooked trout, buffalo steaks and barbecued whole lynx, which was served with an exchange of the latest news. Hawes is thought to have died with his family while attempting to raft down the Fraser River in 1813, but his Christian name remained with the first and succeeding forts, to be used again when the National Park was created, and again when the town of Fitzhugh was re-named Jasper.

The next post established was that of William Henry, in 1806. Located across the Athabasca from the present Jasper townsite near what is now called Old Fort Point, this fort was primarily used during the winter by men whose duties were to look after the string of Northwest Company horses that wintered on the open snow-free flats. Little remained of this post by 1863, but the locality was noted as the turning off point where the westward-bound traveller left the Athabasca and turned northwestwards up the Miette River to the Yellowhead Pass.

* Geologist, Canadian Superior Oil of California, Ltd.

David Thompson, the great geographer and fur trader, passed through the Athabasca valley on his way westward during the winter of 1810-1811. His trip through the Athabasca Pass was a detour necessitated by warring Piegans on the North Saskatchewan River where he had camped near Rocky Mountain House on his way through a more southerly pass. A glimpse of Thompson's tremendous determination is revealed in his diary notes as he describes the journey by pack horse and dog sled. Leaving Rocky Mountain House on October 28, 1810, and arriving on the Athabasca on November 29, he camped with his small party of French-Canadian Voyageurs and Indians just beyond Jasper House for 25 days preparing dried meat and making snow shoes and sleds for the hazardous mid-winter crossing of the Rockies. Jasper House was then deserted and consisted of a small, dirty hunter's cabin without windows. On December 2 the preparations were complete, and the party continued with 70 pounds per sled, pulled by two dogs each, with four horses carrying 208 pounds of pemican, 35 pounds of grease, and 60 pounds of flour. He journeyed up the Athabasca beyond the present town of Jasper to the mouth of the Whirlpool, thence up the Whirlpool River and over the pass where he found the snow so deep that ground could not be reached with a twenty foot pole. A scaffold of trees was cut to camp on. Before reaching the pass, Thompson records:

> "we came on the track of a large animal, the snow about six inches deep on the ice; I measured it; four large toes each of four inches in length to each a short claw; the ball of the foot sunk three inches lower than the toes, the hinder part of the foot did not mark well, the length fourteen inches, by eight inches in breadth, walking from north to south, and having passed about six hours. We were in no humour to follow him; the men and Indians would have it to be a young mammoth and I held it to be the track of a large grizzled bear . . . "

If not the best of this district's grizzly bear stories, this account must surely be credited as a "first." However Thompson apparently did not find the Athabasca valley abounding with game such as the much later men who built the railroads did. He mentions fresh buffalo tracks, but camp meat must have been in short supply for he expressed much concern over the appetite of his French-Canadians who devoured 56 pounds of pemican during the 36 hours spent in going over the pass. The fluctuations in game population of the area are apparently nothing new, an encouraging fact in view of the recent great decline of animal life in Jasper National Park.

Thompson reached the Columbia River on January 26, 1811, and returned laden with furs in May of that year, thus becoming the first white man on record to cross the Athabasca Pass. Thompson's mapping was surprisingly accurate and served as a guide to this area for many years.

During the next 51 years to 1862, continued use was made of the Athabasca Pass by brigades such as Gabriel Franchere's, who was forced in 1814 to make the overland return to the east with a party of 76 men, exclusive of families, when Indians destroyed his ship, the "Tonquon" at his post on the mouth of the Columbia. In Franchere's day the Athabasca trail was travelled twice a year by fur brigades moving between the Pacific and Hudson's Bay which he describes as "picturesque cavalcades, startling the silence of the mountains with jingling horse-bells, the gay chansons of the voyageurs, sharp words of command, shouts and cries to obstreperous pack ponies." Travelling westward from Edmonton to Jasper House, the trip was made in summer by horse, in winter by dog teams and snow shoes. At the mouth of the Whirlpool River, the horses

were usually sent back and the rest of the journey to Boat Encampment (the mouth of Canoe River on the Columbia) was made on foot. Returning canoes were usually taken from what is now Jasper to Lac St. Anne by French Canadian voyageurs.

Franchere was followed eastward by Ross Cox, 1817, with a party of Pacific Fur Company people numbering 86 including women and children.

Next came Sir George Simpson, governor of the newly amalgamated Hudson's Bay and Northwest fur companies, in a visit of 1824. Then, returning with Simpson the next year, came Alexander Ross who, like Cox before him, had been working for the Astor Trading Company on the west coast before it was bought out by the North-west Company.

Thomas Drummond, naturalist, crossed in 1826, with David Douglas the botanist, and Edward Ermatingter, in charge of the Hudson's Bay Express, close behind in 1827. They left Vancouver in March of that year and arrived at Jasper House in May. Douglas carried with him 40 pounds of the seeds of the fir tree that now bears his name. The first use of the lower Yellowhead Pass, (elevation only 3711'), appears also to have been made during that year, by a New Caledonia packet consisting of George McDougall and four men who had battled their way east on foot from Tete Jaune Cache to Jasper House. These were the years in which civilization was becoming entrenched in Eastern Canada and the United States, but the colonization of the western prairies was not being encouraged by the Hudson's Bay Company or its great competitor, the Northwest Company. During this time the union of these companies took place in what was possibly the greatest land deal ever made in this country. In a ponderous indenture of 10,000 words signed on the 26th of March 1821, the Hudson's Bay Company, which virtually held control of all lands within the Hudson's Bay watershed, joined with the Northwest Company, which controlled the rest of the plains and foothills area. After the merger, a new and better post of Jasper House was constructed by Michel Klyne in 1826 opposite the mouth of the Rocky River near the present site of Devona, on the shore of Jasper Lake. This post remained in operation, although not continuously, from that time until 1884, when it was closed and not again reopened.

James Douglas, later to be the first Governor of British Columbia, camped at Henry House on his way up the Athabasca on October 11, 1835. Following the agreement of 1839 with Russia for a lease of a strip of the Alaska coast line, the Hudson's Bay Company sent four men with 20 servants to take possession of the Russian establishment at the mouth of the Stikine River. Some of the members of this party travelled overland by way of Jasper with the Columbia brigade, and the following year, 3,000 otter skins which was the rent to be paid to the Russian Government, were sent across the mountains.

In the spring of 1846, the Belgian missionary, Pierre Jean De Smet, arrived from Edmonton in a cariole drawn by four dogs, and spent 26 days in the vicinity of Jasper. He then camped at the head of the Athabasca Pass where he cheerfully undertook a fast of 30 days to reduce his corpulence sufficiently to enable him to continue his journey to the Columbia, for the first time in his life, on snow shoes. At the summit he met the Hudson's Bay brigade with which Captains Ward and Vavasseur of the British army were travelling.

Still using the Athabasca Pass, Paul Kane, artist and author, crossed on snow shoes during the winter of 1845-46. Dr. Hector of the Palliser Expedition visited the Athabasca valley in the winter of 1859.



ON THE WAY TO JASPER IN THE OLD DAYS

The Red River carts, made entirely of wood without a single nail, were used for crossing the great plains. It took two months from Fort Garry (Winnipeg) to Edmonton, and three weeks more, with pack horses, to reach Jasper. Note the Indian teepee of buffalo skin.

Photo by Horetzky, reproduced by permission G. S. Hume.

INDEX MAP: JASPER AREA



SCALE

Miles 8 6 4 2 0 8 16 24 32

JAH Jul 11/55



ROCHE MIETTE

Photo by F. G. Fox.

PLATE NO. 2

The year 1860 saw different and significant developments in the history of Jasper, when a Mr. Laurin and three companions passed eastward through the Yellowhead Pass on their way from the Cariboo with around 1600 dollars worth of gold. This helped start the Cariboo Gold Rush and two years later a large party including one woman with children left eastern Canada to seek their fortunes. The story of this party's journey as told in the diary of A. L. Fortune, is one of the most interesting, as 150 people crossed the prairie by cart from Winnipeg to Edmonton, by horse and foot through the Yellowhead to Tete Jaune Cache, only then to realize they could not cut directly through to the Cariboo, but must face the unknown perils of either rafting down the treacherous Fraser River, or seek a way via the North Thompson to Fort Kamloops. The party split up at Tete Jaune, some going south to the North Thompson, others taking the raft trip down the Fraser which they accomplished with only slight loss of life, complete with their horses on following rafts. By the time they reached the Cariboo gold working, the boom was over. However, the members of this party, as they scattered over British Columbia, did much to publicize both the advantages of the Yellowhead route, and the fertile lands of the western prairies which had previously been regarded as rather unfavorable for agriculture.

First of the tourists were W. F. Milton and W. B. Cheadle, a pair of English writers and adventurers, who left Edmonton on June 3, 1863, and passed by Jasper House on June 29, on their way up the Athabasca River. They describe the Indians then in the valley as Shuswaps, lean, wiry men of middle stature and smaller than the plains Indians, with features more finely cut. The Indians were peaceable and honest, with no tents, horses, or dogs; their only tools were a knife and an axe. On July 9, 1863, Milton and Cheadle crossed the Yellowhead Pass, scarcely realizing that they had entered the Fraser watershed, the ascent had been so gradual. Mt. Fitzwilliam (see PLATE No. 4) was named by them at this time. The widely read and entrancing volume of this trip, published in 1865 and frequently reprinted, awakened interest in utilizing this pass for a trail route, especially since in the year 1867 the Dominion of Canada was formed and men turned westward to settle the plains. After the Hudson's Bay rights were bought up in 1869, a strong threat to the Dominion's hold on the vast western prairies developed from the enthusiastic spread of American settlement and railroads as they spread northwards. To meet this challenge, the then separate province of British Columbia was coaxed into the confederation with the promise of a trans-mountain railroad. In 1872, just one year after B.C. joined, the route for the Canadian Pacific Railroad was surveyed through Jasper. That same year, Sanford Fleming, Engineer-in-Chief, made a personal inspection of the proposed line. Fleming's trip from Edmonton to Jasper House was made in fifteen days, before and during which the party lived on the standard fare of pemican and flour. The secretary of the party, Grant, extols the virtues of pemican in his book recording the trip. He describes it in all seriousness as "good either cooked or raw, keeps for 20 or 30 years, is wholesome and strengthening, portable, and needs no medicine to correct a tri-daily use of it. Furthermore, a bag weighing 100 pounds is only the size of a pillow." Their Sunday treat on this trip was "plum pudding" made of pemican, boiled in a flour sack, and covered with brandy. An accident which cost the party one of their bottles of brandy saved expressly for this use, occurred while rounding the rock point formed by the northwest spur of Roche Miette. Although the secretary records "the most serious losses are taken calmly and soon forgotten," the name Disaster Point is still used for this locality, and an Alpine Club hut nestles near the spot.

Fleming was well satisfied with the route surveyed by Walter Moberly through the Yellowhead, since the maximum grade in the Jasper area did not exceed one half

of one per cent, but for political reasons the first trans-Canada railway was constructed through a more southerly route. Not long after its completion, the Grand Trunk Pacific was built from eastern Canada to Prince Rupert, passing through Jasper in 1910. This rail line was closely followed by yet another, the Canadian Northern, which linked Edmonton and New Westminster, and was completed through Jasper in 1913. The need for steel rails for the war resulted in the partial amalgamation of the two railroads in 1916, with the better parts of each line along the Athabasca trail being joined to form the Canadian National Railroad. Most of the present highway from Jasper to the eastern edge of the Park is built on these abandoned grades.

Towns sprang up to service the rail lines and develop the natural resources. Lucerne, on the westward side of the pass, became a divisional point for the Canadian Northern, while Jasper became the Grand Trunk divisional centre. Rivalry was keen between the two towns, especially after 1917 when it became apparent that both rail lines from Edmonton to Red Pass were not needed, and one or the other of the towns must go. A Board of Railway Commissioners ruled in favor of Jasper, and in 1924 the people of Lucerne moved to Jasper. The closing of the modern coal mine at Pocahontas in 1923 after 13 years of mining operation, and the town of Brule in 1928 after 14 years of operation, left the village of Jasper supreme and alone on the Yellowhead route through the Rockies.

Jasper village is unique in many regards, since all governing is still done by the Dominion Government through an autonomous person, the Park Superintendent. No town council or mayor exists, or is needed, since all administration is carried on by federal civil servants. The townsite is located within the National Park primarily to attend to the needs of the Park and railroad, so its growth for other industries is not encouraged. No one person may lease more than one town lot; property ownership is limited to the buildings and business on the lots, with the only privately owned land within the Park originating as a homestead taken out in 1891 by the late J. L. Swift, pioneer resident and only farmer of the valley. Swift refused to sell his quarter section just 7½ miles north of town to the government when the Park was created in 1907.

THE MOULDING OF A NATIONAL PARK

Although created in 1907 with the present boundaries fixed in 1914, it was not until after the railroads had arrived and the First World War was over that development of the Park began in earnest. First came the construction of pony trails, telephone lines, and living quarters in remote areas for the Park Wardens. Since the only means of transportation was by pack horse, a common sight was a thirty horse pack train being herded out of town laden with food and building materials with the Warden's wife in the lead holding onto a child seated on a pillow in front of her. Trails and single-wire telephone lines were soon pushed to the very extremities of the Park, as men sought to be ready for forest fires and poachers. The largest fire to ravage the Park, occurred during these early days at Fortress Lake, when two hundred head of pack horses were needed to carry food and fighting equipment. Today's communications are very different, with portable radios now being used in some areas, fire lookout towers manned all summer long on strategic vantage points, and a constant highway patrol being maintained throughout the year.

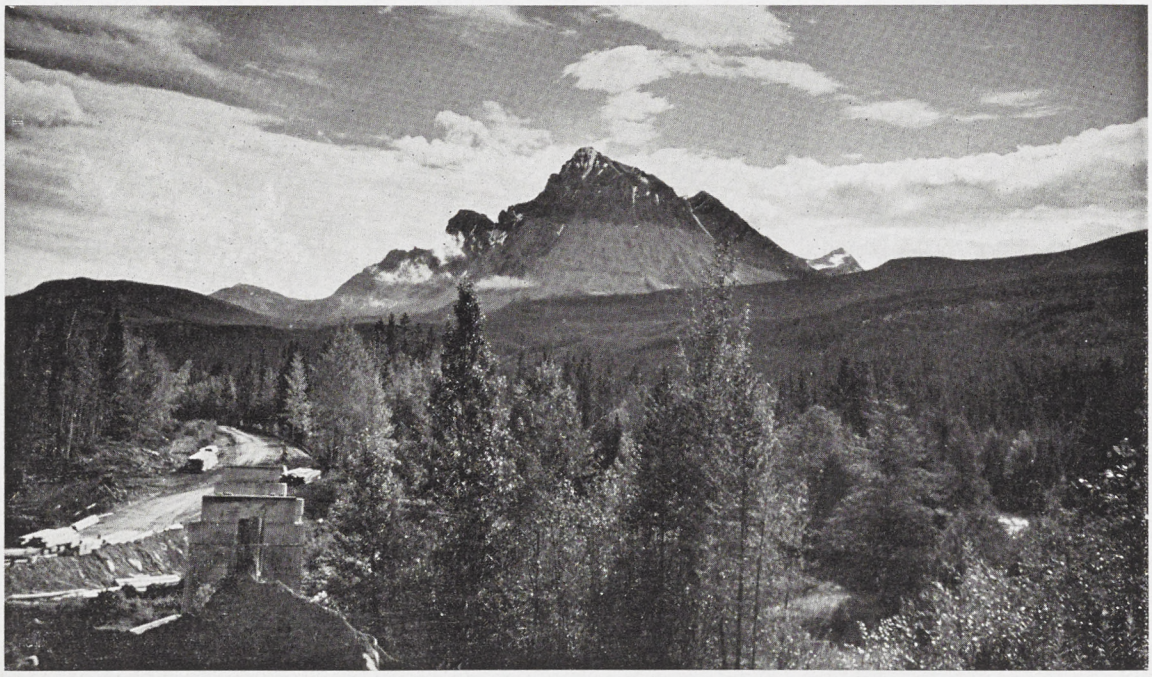
Fishing has always been one of the Park's strong attractions. Although native Dolly Varden or "Bull Trout" were common in many lakes and streams, the barren watersheds such as the Maligne were long ago recognized as great potential fishing areas. After several years of study, 50,000 Speckled Trout fry were carried by team



ROCHE MIETTE AND JASPER LAKE FROM MT. GREENOCK

Rocky river below Roche Miette, Athabasca river to left. Jasper House was on the extreme left of the view. Photo by Bridgland, reproduced by permission G. S. Hume.

PLATE NO. 3

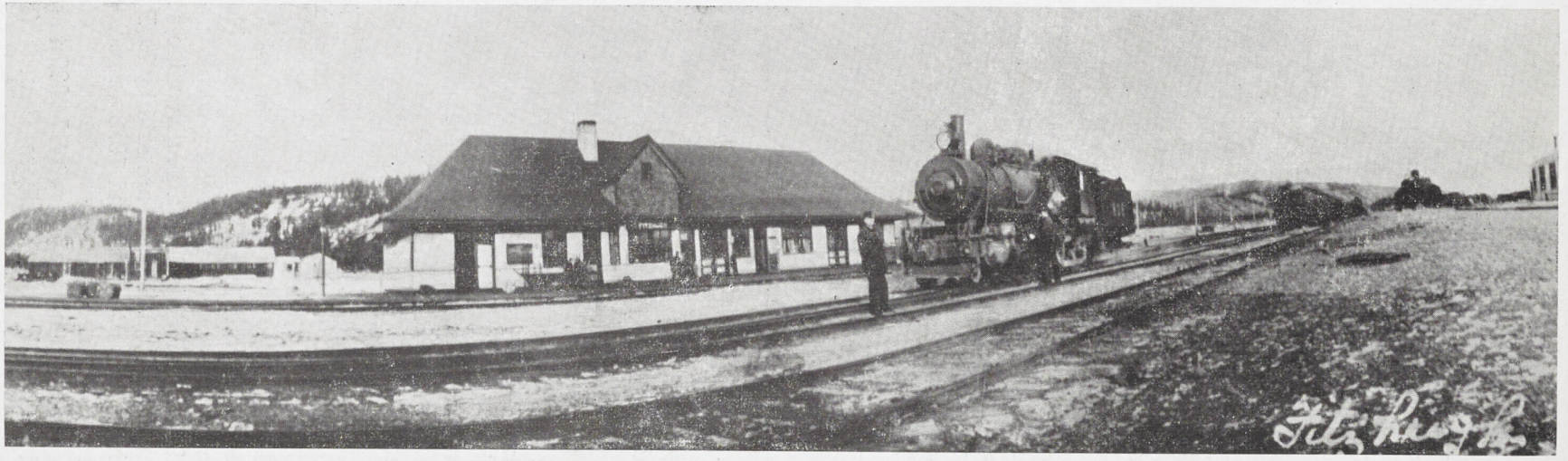


Mt. Fitzwilliam, B.C. Photo by M. K. Sorenson

PLATE NO. 4



Looking north and east from Jasper in 1912; present village developed where tents can be seen on left of plate.
PLATE NO. 5
Photo courtesy Ross McKee.



The village of Jasper in 1912 taken looking north and west at the original Grand Trunk Railway station of Fitzhugh.
PLATE NO. 6
Photo courtesy Ross McKee.

and pack horse to Maligne Lake. The choice of fish and locality has since proven to have been excellent, since they grew and multiplied at a record breaking rate. Thus encouraged, other species of fish, mainly the fighting Rainbow, were introduced into Jasper's lakes and streams. Despite being heavily fished, a fair enough fish population has been maintained.

The Jasper Park Lodge began as a tent camp on the shores of what was then Horseshoe Lake in 1915. After the first log cabins were built in 1922, the present Lodge began to take shape, and by 1923 the first part of the main building was finished. Largely through the efforts of Sir Henry Thornton of the Canadian National Railway, the Lodge was enlarged to nearly its present size by the completion of the many cabins surrounding the shores of Lac Beauvert. Much of the great craftsmanship in log building was recently destroyed when the main building burned to the ground.

THE GEOLOGISTS CAME

Dr. Hector (1863) of the Palliser Expedition was the first geologist to visit the Jasper area. During the winter of 1858-1859 he made a number of observations in the valley relating to the weather, topography, animal life, and such geology as could be seen through the snow. The wind-swept ridge of Roche Miette revealed to Hector the following section:

(a) Hard compact blue limestone and shale, with nodules of iron pyrites--- 2,000′

(b) Fossil shales, almost black ---------- 300′

(c) Hard grey sandstone ---------- 100′

(d) Shales towards the upper part, with green and red blotches ---------- 500′

(e) Cherty limestone and coarse sandstone obscured by timber ---------- 2,000′

He did not assign an age to these units, nor did he attempt any geological mapping.

In 1898 James McEvoy of the Geological Survey of Canada spent the summer in the Jasper and Yellowhead Pass area, and like Hector before him, his only stratigraphic section was that on Roche Miette (1901). He recognized the Devonian strata at Roche Miette and on other peaks correctly applied the then current name of "Banff" to the Mississippian rocks. McEvoy thought the term "Bow River" could be applied to the quartzites and conglomerates exposed a few miles north of Jasper which are overthrust onto later Paleozoics forming The Palisade. His correlation, which was based only on lithological grounds, indicated a possible Cambrian age of these rocks.

Through the years 1910 to 1930 the coal discoveries near the railroads on the eastern ranges attracted the attention of D. B. Dowling (1912) and J. MacVicar (1917, 1920) and B. R. MacKay (1929, 1930) who published reports dealing with the area's general geology with emphasis on the lower Cretaceous coal-bearing "Kootenay" formation. During these years, considerable industrial development began to take place in the Athabasca valley, starting with the opening of a modern coal mine at Pocahontas in 1910, and followed by a similar mine across the river at Brule in 1914. Dirty coal and structural difficulties are said by B. R. MacKay (1930) to have caused the closing of these mines in 1923 and 1928 respectively. Meanwhile, limestone was being quarried and crushed in a large plant four and one half miles north of Jasper. This rock was taken during the years 1917-1930 to supply limestone for the manufacture of Portland cement by the Marlboro Cement Co. Ltd. near Edson. According to Goudge

(1946) the limestone was needed when local marl deposits near Edson proved unsatisfactory. Goudge also mentions that at this time a fairly large lime plant was being operated by the Fitzhugh Lime and Stone Co. at Disaster Point west of Roche Miette.

Among the first to publish accounts dealing primarily with the Paleozoic succession were E. M. Kindle (1929) and P. E. Raymond (1930). Under the latter's direction, Collet and Parejas (1932) prepared accounts of the Paleozoic stratigraphy and published a cross-section along the Athabasca River. Raymond subdivided the Devonian into seven lithologic zones with six new names; however, only the basal two units are now known by his names, the Flume and Perdrix, because Raymond, by failing to note the structural complexities of Roche Miette and Disaster Point, described some of the same beds twice.

W. A. Kelly (1939), who was associated with MacKay in the mapping of the Mountain Park area, suggested the term "Blackface Mtn. shale" for the middle beds of the Devonian series. Allan, Warren and Rutherford (1932) proposed the adoption of that name and recognized the correlation of this unit with the lower part of the "Minnewanka" (Fairholme) of the Banff area. Although of a reconnaissance nature, the work of Allan, Warren and Rutherford established broad, regional correlations of all major rock units and thus marked the closing of the reconnaissance era in Jasper's history of stratigraphy.

Later investigations by Allan dealt with the Triassic in the Mowitch Creek area north of Jasper (1933) and the Cambrian of the Sunwapta Pass area (1938). More recently, Lang (1947) mapped the Brule area and his memoir includes a summary of Devonian nomenclature problems.

In a paper dealing with the Devonian fossils of Alberta, P. S. Warren (1949) established five fossil zones applicable to the Devonian of the Jasper area. McLaren (1954) has since proposed seven Rhynchonellid zones for the same strata (minus the Exshaw). Both papers greatly assist the correlation of rock units in the Jasper area with other parts of Alberta. Undoubtedly the most useful recent contributions to our knowledge of the Devonian stratigraphy at Jasper were written by Fox (1951) and deWit and McLaren (1950). Both papers give excellent stratigraphic sections which are broken down into readily recognized rock units some of which may be approximately correlative to the standard Devonian units of the Alberta plains. Their convincing correlation of the Fairholme reefs of the Banff area with the shales in the Perdrix, Mt. Hawk and Alexo (or Cheviot) of the Jasper area, sparked many oil companies into similar stratigraphic studies. It seems reasonable to assume that if these studies had been completed at an earlier date, the search for Woodbend reefs under the Alberta plains would have commenced much sooner than it did.

Severson (1950) studied the unusually thick Devonian together with the underlying Silurian and Ordivician rocks at the Sunwapta Pass area. Beales (1954) discussed the similarity of the Palliser limestones and the Bahama Banks sediments.

Mississippian strata were described in great detail by R. A. C. Brown (1952) and published as a memoir. This study has since been continued by P. Harker (1954).

Jurassic strata received attention from many of the above authors: Spivac (1949) includes a Folding Mountain section in his paper devoted exclusively to the Jurassic of the foothills of Alberta. Dr. H. Frebold (1954) is continuing this work.

The pre-Devonian strata of Jasper were recently dealt with by Harker, Hutchinson and McLaren (1954). This paper, in discussing the sub-Devonian unconformity, briefly describes the much-neglected Cambrian, Ordovician, Silurian and Middle (?) Devonian of the Rockies.

No source of information is more acceptable than that provided by the drill. Two wells have been drilled and abandoned near the subject area: the first of these, Shell Solomon Creek No. 1 in Lsd. 6-17-51-27 W.5, spudded in 1942 and was drilled to 4774′ and suspended until 1953 when a group including New Superior and Home Oil, deepened it to 11,327′ before it was abandoned.

The second well, spudded in 1944, was the Jasper Syndicate No. 1 located in Lsd. 2-19-49-26 W.5 on an indicated anticline. This test was drilled to 5096′ by the team of Imperial and Anglo Canadian. Surface geological work was done by Jack Webb and H. Kunst; wellsite geologists were Walter Brown and Bill Hancock. The well was a tremendous stratigraphical success, albeit an economic failure.

From the days of Hector's brief description of Roche Miette to today's detailed reports held in confidence by many oil companies, the Rockies of Alberta have yielded an enormous wealth of stratigraphical material. As each formation becomes economically important on the western plains and foothills, no doubt its mountain equivalent will continue to receive greater attention. We may yet come to realize that today we are like the university student who, with the first year behind him, feels he knows it all, but who later goes on to find that after completing the course, his learning has only started. In the years ahead the mountains will still be waiting.

TOPOGRAPHICAL MAPS

Details of the mammoth task of surveying the topography of such a mountainous region are not within the scope of this paper. However, one part of the story as told by Cautley and Wheeler (1924) concerning the Alberta and British Columbia boundary survey is well illustrated and would be very useful to anyone contemplating geological studies along the border. A series of maps accompanies the book.

Excellent topographic maps, on a scale of one inch to three miles, cover the area of Jasper National Park in separate North and South sheets. These maps may be obtained from the Park Superintendent.

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ANNOTATED INDEX TO THE CAMBRO-ORDOVICIAN OF THE JASPER PARK AND MOUNT ROBSON REGION

BY

L. D. BURLING*

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ANNOTATED INDEX to formations and other units, faunas, mountains and other topographic features.

BIBLIOGRAPHY

INTRODUCTION

McEvoy (1900) was the first geologist to describe the succession near Yellowhead Pass. He applied McConnell's terms, Bow River and Castle Mountain, to the clastic lower and the calcareous upper portions, respectively. He quotes (p. 16D) from Milton and Cheadle's original description of Mount Robson (The Northwest Passage by Land), and cites G. M. Dawson who recorded its Indian name as Yuh-hai-has-kun. He publishes (pl. II) a photograph, and maps the mountain as exposing rocks belonging to the Castle Mountain group.

Walcott (1913b, pp. 339-340) speaking of the basal Cambrian and the pre-Cambrian in the vicinity of Yellowhead Pass says: "To the south of the Pass, the banded cliffs of Cambrian rocks in Mount Fitzwilliam and Mount Pelee rise high above their bases of Miette sandstones. At the Pass the valley is essentially the same type as the valley of Bow River near Lake Louise station. In both, the valley is eroded in the Belt series of impure sandstones, and the Cambrian sandstones and limestones form high bold mountains to the north and south of the valley." (See also Miette formation.)

Walcott (1927, p. 172) describes the Robson trough as "now bounded on the southwest by Proterozoic Beltian sandstones and shales of the ridges of Little Grizzly and Whitehorn peaks . . . and on the northeast by the great Moose Pass fault that extends from Moose Pass south-southeast and north-northwest . . . The trough has a width of 14 miles on a line extending from Moose Pass southwest to Little Grizzly Peak . . . The

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known Paleozoic deposits of the Robson trough have a thickness of 13,300 feet, exclusive of any that may have been deposited east of the Moose Pass Fault . . . It is to be noted that in the Robson and Glacier Lake districts the known Upper Cambrian rocks are east of the continental Divide and in the Bow-Kicking Horse area they are west of the divide."

E. M. Kindle (1929a, pp. 178 and 179) says that "the mountain ranges of the Jasper Park region trend in a northwest-southeast direction. Four major thrust faults trending in the same general direction as the mountain ranges are the large factors in repeating the Paleozoic section along Athabasca River between Brule and Jasper . . .

"A map by Allen published in 1925 in two colors (undifferentiated Paleozoic and Lower Mesozoic, and Lower Cretaceous) indicates plainly the northwest-southeast trend for more than 350 miles, of the structural features which in western Alberta have given rise to the Rocky Mountains and the Great Plains east."

Raymond (1930a, p. 289) speaking of the Jasper Park region, says: "Cambrian is to be seen in three bands . . . The most eastern is along the northeast sides of the Bosche and Miette ranges, where it is thrust over Cretaceous. The second appears in Mount Chetamon, crosses the Snaring River and extends for some distance along the base of The Palisades. The third, a very large one, as yet incompletely studied, includes upper parts of Pyramid and Signal Mountains, Mount Edith Cavell, and many mountains in the Tonquin Valley. This area extends across the divide at Yellowhead Pass and is of the same facies as the Cambrian of the Mount Robson district." "No formation (Idem, p. 293) younger than the Lower Cambrian Cavell quartzite has been seen in Jasper Park west of the Pyramid fault."

Allan, Warren, and Rutherford (1932, p. 229): the Devonian and Carboniferous are "composed essentially of limetones and are represented in each of the great fault blocks which form the mountain ranges. Upper Cambrian beds occur in the succession below the Devonian on Roche Miette toward the east end of the section, and the lowermost Ordovician, probably overlying beds of Cambrian age, is present beneath the Devonian in The Palisade fault block at the west end of the section. Between these two points Cambrian and Ordovician rocks do not appear. This may be due to non-deposition and it is possible that the lower Paleozoics of Roche Miette and The Palisade were deposited in separate seaways . . .

"Pre-Cambrian beds are faulted against the Paleozoics at the western end of the section. It is probable that a considerable development of pre-Cambrian rocks lies to the west of the area studied" (Pyramid Mountain to Folding Mountain).

Kelly (1939, p. 2000) describes the lower 1,500 feet of the 4,500-foot Paleozoic section in Jasper Park as unfossiliferous and correlatable on lithologic grounds with Walcott's Sarceen series of Ozarkian age. An immediately overlying steel-gray granular dolomite, 150 feet thick, "with a coralline fauna of Devonian aspect," is correlated with the Lower Minnewanka of the Banff section.

GEOLOGICAL BOUNDARIES

CAMBRIAN AND PRE-CAMBRIAN

Walcott describes this boundary (1913b, pp. 329-330) as finely shown "to the north, west, south, and southwest of Yellowhead Pass, in Mount McEvoy, Yellowhead Mountain, Mount Fitzwilliam, Mount Pelee, and other high points from 8 to 20 miles east to the mouth of Moose River." He speaks of an unconformity, and of a

general tendency for the pre-Cambrian rocks of the Miette series to look as if they had been laid down in muddy water. The line is also described as difficult to draw.

Around Mount Robson he (1928, pp. 357-358) describes Lower Cambrian McNaughton sandstones in contact with the Miette at high angles in Robson West Station (7,330 feet), west of Lake Kinney; and in Lake Kinney Station (6,849 feet), a ridge above Rainbow Brook.

Raymond (1930a) finds pre-Cambrian rocks beneath the Lower Cambrian Cavell quartzite in Jasper Park, but considers them sufficiently distinct from Walcott's description of the Miette to receive a new name—the Jasper Series.

McEvoy's descriptions of the rocks in Mount Robson and in Yellowhead Pass, which are quoted under these headings, suggest that there may be two pre-Cambrian series additional to the Shuswap which occurs southwest of the McLennan River.

LOWER AND MIDDLE CAMBRIAN

Walcott (1913b, pp. 338-339) placed the boundary between the Lower and Middle Cambrian between the "Hota" and the Chetang, and transferred the "new Lower Cambrian subfauna," found near Mumm Peak, from the Mahto (Walcott, 1913a) to the "Hota." This exaggerated the Lower Cambrian aspect of the Hota, because the fauna really belongs in the Mural limestone, 1,750 feet below the Hota, but *Olenellus* fragments have been secured from the Hota at two Mahto Mountain localities.

The problem is comparable to that in the Canadian Pacific Railway section. There a Mount Whyte formation was long called Lower Cambrian because of the presence in it of fragments of *Olenellus canadensis*. This persisted during years in which the Mount Whyte was believed to contain a fauna with as definite a Middle Cambrian aspect as the *Albertella* fauna. It is still being called Middle Cambrian by some, Lower Cambrian by others, even though the *Albertella* fauna was located correctly in the overlying Middle Cambrian Cathedral over 35 years ago.

Here, in the Mount Robson region, a formation, the Hota, which Walcott (1928, p. 253) compares to the Mount Whyte, holds the key to the boundary between the Lower and the Middle Cambrian. The Hota, as a formation between unfossiliferous Lower Cambrian Mahto (Walcott, 1913b, p. 339) and the *Albertella*-bearing Chetang, has been found in two general localities 2.5 miles apart: (a) in Mount Mumm, where it has well-defined Middle Cambrian fossils, top to bottom, and (b) in Mahto Mountain where *Olenellus canadensis* fragments have been found in the top layers of the formation and 300 feet below it. The obvious implication that one and the same formation is Lower Cambrian in one place and Middle Cambrian in another requires study.

The lithology of the Hota varies between the two general localities; (a) in Mount Mahto it is predominantly clastic and carries fragments of the one *Olenellus* species which has lasted into the Middle Cambrian elsewhere; this is the Hota facies; (b) in Mount Mumm it is calcareous and abundantly fossiliferous, but the fossils are Middle Cambrian; this is the Adolphus facies. If we interpret the fragments in the Mahto-Mountain Hota (a) as traces of remnant Olenellid faunas which persisted after the introduction of the Middle Cambrian, and the Mumm Peak limestone (b) as having been deposited in a sea so calcareous that *Olenellus* shunned it, the two formations are stratigraphically one, and careful search of the Hota facies should be rewarding. The line should certainly be drawn above the Mural with the unequivocal "new lower Cambrian subfauna" of locality 6lk. Exactly where to draw the line is more difficult. In the Mumm Peak section, the first beds resembling the 20-foot calcareous bed with

Olenellus and *Bonnia,* which has been described (Burling, 1914, pp. 106 and 115) as forming the top of the Lower Cambrian in the Canadian Pacific Railway section, occur approximately 1,000 feet below the base of the Hota.

In the Mount Robson region (Burling, 1923, pp. 730 and 742) an apparently unfossiliferous, dominantly quartzitic series (the Mahto) separates a formation with known Lower Cambrian (the Mural) from the Middle Cambrian Hota. The boundary between the Lower and Middle Cambrian is arbitrarily drawn at the top of the Mahto where the change from sandstone- to limestone-forming conditions is fairly abrupt, rather than at the lower more or less transitional boundary.

MIDDLE AND UPPER CAMBRIAN

Walcott (1913b, p. 337) drew the line between the Middle and Upper Cambrian at the base of the "unfossiliferous" Lynx limestones and above the Titkana limestones in which he had found a fauna comparable with that of the Stephen in the Canadian Pacific Railway section. The discovery of shallow-water deposition at the chosen line (Burling, 1915, pp. 87-88; 1916a, p. 99; 1917, pp. 145-149, and 1923, p. 729), with abundant Middle Cambrian fossils below and Upper Cambrian fossils above it, confirms, for the Mount Robson region, a lithologic and stratigraphic break which has necessitated, in the sections a hundred miles and more to the south, the creation of an Arctomys formation with its mud-cracks, ripple-marks, and casts of salt crystals, sometimes associated with a characteristic down-warping of the beds, which prove subaerial desiccation. But, identical lithology need not mean equivalent age.

CAMBRO-ORDOVICIAN

Walcott (1913b, p. 337) found no fossils "below an arbitrary line drawn at the base of the shaly limestones carrying the fauna of locality 61q" in The Extinguisher (Walcott's Billings Butte), and the line between the Lynx and Robson formations was called the Cambro-Ordovician boundary.

He says "there is no known well-defined lithological break between the Ordovician and the Cambrian. A line is now tentatively drawn in a series of thin-bedded and shaly limestones, at Billings Butte (The Extinguisher), where there is a commingling of the lower Ordovician and Upper Cambrian faunas."

This faunule has been discovered in place (Burling, 1923, pp. 727-729) and in known relations to a far greater section of the underlying rocks in the top of Iyatunga Mountain (Wheeler's "Rearguard"). But the top of Iyatunga Mountain unfortunately exposes nothing higher than does The Extinguisher. (See Chushina for interpretations of this section.)

The varve-like lamination which E. M. Kindle (1929a, p. 186) describes for bed 5 of his section in The Palisade, is regarded by him as a special facies of Upper Cambrian sedimentation preliminary to the segregation of the immediately succeeding special biota of bed 4 which he calls Mons, and which C. H. Kindle correlates with the *Symphysurina* zone.

Raymond (1930b, p. 305) speaking of the age of the Mons and Chushina faunas said that he was particularly impressed by the "similarity of conditions at the end of the Cambrian in the Canadian Rockies and Vermont." In neither is there "evidence of emergence of long duration," but in both "intraformational edgewise conglomerates indicate shallow water and brief emergence,"and "the occurrence of fossils is sporadic . . . " The "brachiopods of both the Mons and the Chushina are decidedly Upper Cam-

brian . . . it is in the trilobites that one sees the new order of things." The trilobites are discussed in detail, the Ordovician indication of *Symphysurina, Xenostegium, Hystricurus,* and *Leiostegium* in particular. He cites *Kainella* as a Dikellocephaloid hangover from the Cambrian, and *Dictyonema* as going far toward upholding his contention that the Chushina fauna is oldest Ordovician. "As in the east (Vermont), certain elements of the Cambrian linger, but the Ordovician types predominate . . . There is no difficulty in distinguishing the fauna of the Sabine from that of the Mons . . . it is a practical and logical place to draw the line between Upper Cambrian and Ordovician." (See Sabine.)

GENERALIZED SECTIONS

The following sections include the names of all Cambrian and lower Ordovician formations used for the Mount Robson and Jasper Park areas.

ROCHE MIETTE

(E. M. Kindle, 1929a, pp. 179-180)

Devonian Minnewanka.

Upper Cambrian (in nine zones):

9.	Many beds in middle, have salt hoppers; layers show a very fine periodic lamination	±900 Feet
8.	Heavy-bedded limestones	±600 "
7.	Covered	±350 "
6.	Heavy-bedded limestone, weathering buffish-brown	50 "
5.	Very thin-bedded limestones and shales, with trilobite fragments	8 "
4.	Green clay shale	20 "
3.	Buffiish-brown weathering limestone	35 "
2.	Covered	75 "
1.	Has oolitic limestone bands	±65 "

(Raymond, 1930a, pp.290, 292-293, and 300)

Middle Devonian Flume	400-1,800 Feet
Lower Ordovician Mons dolomite	800 Feet
Upper Cambrian:	
Snaring formation (dolomite and shales):	
Zone 7	150 Feet
Zone 6 (with salt-crystal pseudomorphs)	90 Feet
Chetamon formation (limestones):	
Zone 5 (with *Billingsella*)	50 Feet
Zone 4 (with Middle Cambrian fossils)	150 Feet
Middle Cambrian:	
Bosche formation (limestone and shale):	
Zone 3	200 Feet
Zone 2 (with trilobite fragments)	300 Feet
Zone 1 (with green shale, poorly exposed)	base
Lower Cambrian:	
Cavell quartzite	(estimated) 3,000 Feet

		Walcott, 1913[1]	Burling, 1923[2]	Walcott, 1928[3]	Burling, 1955[4]
Ordovician		Robson with fauna of 61q at base ---------- 3,000	Nothing higher seen than 1a and 1b (Walcott, 1928, p. 366)	Robson ---------- 500	Computations seem to bring the summit of Mount Robson and the *Kainella* fauna of Locality 61q together.
			Beds of 1a and 1b with fauna of 61q -- 275	Chushina with 61q 800 feet above base 2,300	Beds of 1a and 1b with fauna of 61q ------- 275
Cambrian	*Upper*	Lynx ---------- 2,100	Lynx ----------5,000	Lynx ----------3,500	Lynx ------- (Min.) 4,225
	Middle	Titkana ---------- 2,200 Mumm ---------- 600 Hitka ---------- 1,700 Tatay ---------- 800 Chetang ---------- 900	Titkana ----------2,550 (*Not present*) (*Not present*) Tatei ----------1,000 Chetang ---------- 900 Adolphus ---------- 400	Titkana ----------2,200 Tatei ---------- 800 Chetang ---------- 900	Titkana ----------2,150 Tatei ----------1,000 Chetang ---------- 900 Hota-Adolphus ------ 400
	Lower	Hota (61k) ------- 800 Mahto ---------- 1,800 Tah ---------- 800 McNaughton ------ 500	Mahto ----------1,200 Mural (61k) -------1,000 *Unnamed* ---------- 400	Hota (61k) ------ 800 Mahto ----------1,800 Tah ---------- 800 McNaughton ----- 500+	Mahto ----------1,200 Tah-Mural (61k) ---1,000 *Unnamed* ---------- 400
Pre-Cambrian		Miette ---------- 2,000+	*Unstudied*	Miette ----------2,000+	*Unstudied*

[1]—Walcott, 1913b, p. 341.

[2]—Burling, 1923, pp. 723-726.

[3]—Walcott, 1928, pp. 364-365; 366-367.

[4]—Burling, 1955.

Locality 61k is the "new Lower Cambrian subfauna" of Walcott (1913a); see Mural and Tah.

MOUNT ROBSON

(North and Henderson, 1954, p. 45)

North and Henderson present a correlation table in which Mount Robson is represented by the following formations: Chushina, 500 feet+ (Gasconade); Lynx, 4,900 feet (Dresbach, Franconia, and Trempealeau); Titkana, 2,500 feet; Tatei, 1,000 feet; Chetang, 1,000 feet; and Adolphus, 400 feet (all Middle Cambrian); Mahto, 1,200 feet; Mural, 1,000; and McNaughton, 400 feet+ (all Lower Cambrian); and Miette (pre-Cambrian. They say (p. 54) that the Middle Cambrian remains about constant at 3,600 feet "between Bow Pass and Sunwapta Pass, and increases 1,000 feet or more between Sunwapta Pass and Mount Robson. (See Lynx formation and Cavell quartzites.)

THE PALISADE

(E. M. Kindle, 1929a, pp. 181 and 186)

Devonian (Zone 2)	2,500 Feet
Sarceen series (Mons, Ulrich's Ozarkian):	
Zone 3	140 Feet
Covered	200 Feet
Zone 4 (with a *Symphysurina* fauna, C. H. Kindle)	10 Feet
Upper Cambrian:	
Zone 5 (with finely laminated varve-like limestones)	±250 Feet
Zone 6 (with alternating beds of hard, semi-lithographic limestone and shaly limestone	±250 Feet

PYRAMID MOUNTAIN

(Allan, Warren, and Rutherford, 1932, p. 231)

Lower Cambrian?: Quartzites.

Pre-Cambrian: Jasper series.

CORRELATED FORMATIONS AND FAUNAS

Formational and other units with which the formations of the Mount Robson and Jasper Park districts have been compared or correlated are the following: Arctomys, Mons, Mount Whyte, Ozarkian, Sabine, Sarceen, Stephen, and Sullivan. Faunas which have been recognized by name are: *Albertella, Briscoia, Dikellocephalus, Franconia, Hungaia* and *Hungia, Kainella, Olenellus, Olenellus-Bonnia,* and *Symphysurina.*

ANNOTATED INDEX*

ADOLPHUS LIMESTONE

The Hota formation was identified by Walcott (1913b and 1928) from four separate localities in two stratigraphic positions. In two of these localities the identification was original and conjectural, respectively: (a) in the upper part of Mahto Mountain

* In most instances, there will be cross-references only when there is no clue in the item to other correlative sources of information. For example, there is no cross-reference to Chetang under Albertella. In the next item (Arctomys) there is likewise no cross-reference to Hitka, Titkana, Snaring and Chetamon; there is additional information under each heading.

as *Olenellus*-bearing beds *above the Mahto,* and (b) in Hota Cliff, unfossiliferous and without observable upper or lower contacts. It was mistakenly identified in two other localities: (c) In Mumm Peak as a cliff of post-Mahto limestone to which the word Mumm was applied, and (d) in a cliff above Mural Glacier, where *Olenellus*-bearing beds *below the Mahto* (and therefore the Mural) were called "Hota."

To only one of the two mistakently identified localities, (c) the Hota in Mumm Peak, was the term Adolphus applied (Burling, 1923, pp. 741-743). This was done in the belief that a Middle Cambrian limestone in Mumm Peak (the Adolphus) deserved a name distinct from that of *Olenellus*-bearing clastics in Mount Mahto (the Hota), even though each occupies the same stratigraphic position, so far as over- and underlying beds are concerned. The type locality of the Adolphus is the limestone cliff overlain by thin-bedded Chetang, and underlain by Mahto, in the top of Mumm Peak.

Walcott's section (1928, p. 362) of the Hota and its fauna, even the reference to it of the Mural-limestone "new Lower Cambrian subfauna" of locality 61k, repeats the section he published in 1913.

ALBERTELLA FAUNA

An early Middle Cambrian fauna of unmistakable aspect which was found (a) in the Middle Cambrian of Montana, (b) as drift blocks in the Canadian Pacific Railway section and assigned to the Lower Cambrian, (c) by Walcott in debris of the Middle Cambrian Chetang limestones, well above any Lower Cambrian, in the Mount Robson district (1913b, p. 338, and 1928, p. 353, footnote), (d) in place in the Middle Cambrian Cathedral limestone of the Canadian Pacific Railway section (Burling, 1916b). See Boundaries: Lower and Middle Cambrian.)

ARCTOMYS

The Arctomys formation (Walcott, 1923, p. 461) does not appear as such in the Mount Robson District, but he (1928, p. 360) says: "Thorough study of the lower 1,000 feet of the Lynx formation may furnish data that will result in correlating the lower portion of the shales and limestones with the Arctomys of the Glacier Lake section 125 miles southeast." On page 246 of the same paper, the correlation is still more definite: at Snowbird Pass in the Robson District . . . "the Lynx formation of the Upper Cambrian has at its base 200 feet of shallow-water arenaceous shales that represent the Arctomys formation." The Arctomys-like beds cap two of the mountains in the Mount Robson district: Hitka and Titkana, and are represented in the Snaring and Chetamon formations east of Yellowhead Pass.

ATHABASCA RIVER, see Brulé Lake, Roche Miette, Bosche Range, Jasper Lake, Snaring River, Medicine Lake, The Palisade, Pyramid Mountain, Miette River.

BILLINGS BUTTE, see Extinguisher.

BOSCHE FORMATION AND RANGE

Raymond (1930a, pp. 289 and 290) describes the Bosche formation as combining zones 1, 2 and 3 of his section in Roche Miette for lithologic and mapping reasons. The name was derived from the Bosche Range, across the Athabasca from Roche Miette. The northeast sides of the Bosche and Miette ranges expose (thrust over Cretaceous) the most easterly of three bands of Cambrian in the Jasper Park region. (See Chetamon formation.)

BRISCOIA FAUNA, see Mons, Chushina, and Snaring formations.

BRULÉ LAKE

Dowling (1912, p. 206) says that the heavy yellowish-weathering bed, underlain by shales and limestones which may represent horizons below the Devonian in Roche Miette, is probably repeated in the cliffs on the west side of Brulé Lake.

CAVELL QUARTZITE AND MOUNT EDITH CAVELL

The eastern cliffs of this mountain (Raymond, 1930a, pp. 289 and 292-293) expose the Cavell quartzite. The contact with the pre-Cambrian is at about 7,600 feet in the slopes above the pass where it is concealed by ice and snow. The top of the mountain is permanently snow-covered but quartzites can be seen to within a few hundred feet of the summit. The Lower Cambrian is estimated to be 3,000 feet thick.

The Cavell quartzite is described essentially as follows: the lowest visible strata of the Lower Cambrian are thickly bedded, very hard white quartzites . . . The great amount of feldspar in the debris suggests a considerable thickness of arkosic beds. Fragments with the borings of *Scolithus* are scattered about . . . The general lithology and nature of the partings suggest the Fort Mountain and St. Piran formations of the region about Lake Louise . . . Lithologically the Lower Cambrian strata in this part of Jasper Park differ somewhat from those in the Robson district, so, for the present at least, the quarzite may be designated as the Cavell quartzite.

The Cavell quartzite is part of a very large band of Cambrian which includes "parts of Pyramid and Signal mountains in the Tonquin Valley . . . No formation younger than the Lower Cambrian Cavell quartzite has been seen in Jasper Park west of the Pyramid fault."

North and Henderson (1954, p. 51) say: "From Mount Robson to Jasper, and southeastward along both sides of the Jasper-Banff highway, the lower cliffs of a great many mountains are formed of thick quartzites. The Lower Cambrian is here about 3,000 feet thick, and in most localities carries a good deal of limestone in the center, with *Olenellus.*"

CHETAMON FORMATION AND MOUNT CHETAMON

"Cambrian strata (Raymond, 1930a, pp. 290 and 291) occupy considerable areas in Mount Chetamon, but exposures are poor where not difficult of access. There was no attempt to measure a section. Dr. Parejas found interbedded quartzite and green shale in the saddle between the two peaks of Chetamon. On the basis of lithology, these beds are supposed to be Lower Cambrian. Above them are shales which furnished what appears to be a Middle Cambrian trilobite. These are followed by dolomite and limestone possibly to be correlated with the Bosche formation at Roche Miette. They are succeeded in turn by a "yellow band" like that on Roche Miette. This consists of shaly limestone and dolomite which sweeps down the southwest shoulder of Mount Chetamon, crosses the Snaring, and forms the lowest cliff of The Palisade west and northwest of Henry House." (See Snaring formation.)

The Chetamon formation was proposed by Raymond for zones 4 and 5 of his section of the Cambrian in Roche Miette, which is cited as the type locality.

CHETANG CLIFFS AND CHETANG LIMESTONES

Proposed (Walcott, 1913b, p. 338, pls. 56 and 57) for two cliffs separated by a hundred-foot talus southwest of Coleman Brook, and accepted by the Geographic Board. He (1928, p. 354) suggests probable faulting between Chetang Cliffs and Hitkana Peak.

The Chetang limestones comprise bluish-gray thin-bedded limestones exposed typically in Chetang Cliffs. An estimated thickness of 900 feet succeeds the Hota of Hota Cliff and of Mount Mahto, and is overlain by the Tatei of Tatei Cliffs. These boundaries were not seen in Chetang Cliffs.

The faunas of the Chetang are: locality 61o, 100 feet below the top, with *Nisusia* sp., *Prozacanthoides charilla* (Walcott), and *Clavaspidella sylla* (Walcott); locality 61p, on top of lower cliff, with *Abertella robsonensis* Resser; and locality 61w, a drift block with *A. robsonensis* and *Agraulos* sp.

Burling (1923, pp. 724 and 741) found fossiliferous Chetang in Mural Brook and in the summit of Mumm Peak above a Middle Cambrian cliff to which the name Mumm has been applied. The rocks in this cliff have been called Adolphus.

CHUPO GLACIER

Walcott's photograph (1913b, pl. 58, fig. 1) shows this glacier as the one reaching nearly to the lower end of Berg Lake. Morainal material yielded locality 61u. (See Chushina formation, Walcott, 1913b; and Mount Robson.)

CHUSHINA FORMATION

Walcott (1913b, p. 336) called the fauna of locality 61q, obtained in The Extinguisher, one indicating the base of the Ordovician. The thin-bedded limestones in which it was secured were assigned to the basal portion of 3,000 feet of Ordovician limestone in the top of Mount Robson, and the line between the Cambrian and the Ordovician was "tentatively drawn within them, at Billings Butte, where there is a commingling of the lower Ordovician and Upper Cambrian faunas." Seventeen species were listed.

Fossils are also recorded from two more localities in the "Robson limestones:" one of these, 61u, from gray, thin-bedded limestones in the moraine of Chupo glacier, "with numerous Lingulae of Ordovician characteristics" (p. 334), is credited with *Lingulella* cf. *manticula* White, *Acrotreta* sp., *Hyolithes* sp., and *Ptychoparia* sp. on page 336. In 1923 (Burling, p. 736) it was suggested that the moraine also collected material from the Middle Cambrian, but Ulrich and Cooper (1938) have seen the material, named the species *Lingulella miltoni,* and called the horizon the Chushina formation of Upper Ozarkian age. The other locality (61n) actually occurs in the upper part of The Extinguisher section and carries a *Lingulepis* apparently identical with *Lingulella (Lingulepis) acuminata* Conrad and *Asaphus* sp. (*Bellefontia* in Walcott 1928, p. 358).

Raymond (1922, p. 208) announced the finding, in Billings Butte (The Extinguisher), of a fauna with *Eoorthis, Syntrophia nundina, Agnostus, Triarthrus, Peltura, Apatocephalus,* and two species of *Illaenus.* He called the fauna (61q of these pages) earliest Ordovician and compared it to the *Ceratopyge* fauna of Europe.

Walcott (1923, p. 458) proposed the formational name Chushina for bluish-gray, thin-bedded limestones in the north slopes of "Phillips and Lynx Mountains" (he meant Lynx Mountain and the unnamed peak one half mile southwest), and in Billings

Butte (The Extinguisher). The base of the formation was so defined as to include not only the horizon of locality 61q itself but also any lower layers of rock containing the same fauna (here called *Hungia*) even though such a definition might very probably include, within the Chushina, strata in the upper part of the Lynx. The *Hungia* fauna was called "typically lower Ozarkian and post-Cambrian." This fauna is the third of the four faunules of the Mons reading from the bottom up (Walcott, 1924b, p. 35). (See Mons for the faunules.)

The upper limit of the Chushina was (Walcott, 1923, p. 458) arbitrarily drawn, due to the absence of faunal evidence, 1,500 feet above the horizon of The Extinguisher's *Hungia* fauna, at the point in the section "where the shales and thin-bedded limestones give way to massive beds of limestone forming the main mass of the upper portion of Robson Peak."

He says that delimitation, in the Glacier Lake district, of a new formation (between the Upper Cambrian Lyell and the Ordovician Sarbach) which could be compared, at least in part, with the fauna of locality 61q, "led to a review that resulted in the decision to arbitrarily delimit the lower portion of the Robson formation as a distinct formation and name it the Chushina formation;" and (Idem, p. 471): "Neither the upper nor lower limits of the Chushina have been determined . . . The fauna of the Billings Butte beds of the Chushina may be compared with that of the lower part of the Mons, but it will be necessary to make a detailed study of the section before a close comparison can be made between the Mons and the Chushina." Formations which Walcott here correlates with the Chushina, as formations in the Sarceen series, are Mons, Goodsir (in part), Red Lion, St. Charles, Notch Peak, and Goodwin.

By 1923 the number of identified species of locality 61q had reached 38, as follows (Idem, pp. 473-474):

Lingulella cf. *desiderata* Walcott.
Lingulella ibicus Walcott.
Obolus ino Walcott.
Acrotreta cf. *idahoensis* Walcott.
Acrotreta cf. *sagittalis* Salter.
Eoorthis cf. *desmopleura* (Meek).
Eoorthis cf. *wichitaensis* Walcott.
Straparollus? lavinia Walcott.
Bellerophon? lavassa Walcott.
Cyrtolites meles Walcott.
Orthoceras robsonensis Walcott.
Agnostus sp. undt.
Menomonia gyges Walcott.
Blountia galba Walcott.
Cyrtometopus? sp. undt.
Moxomia hecuba Walcott.
Hystricurus gallus Walcott.
Hystricurus bituberculatus (Walcott).
Apatocephalus fronto Walcott.
Hungia articauda Walcott.
Hungia billingsi Walcott.
Hungia flacilla Walcott.
Hungia laxicauda Walcott.

Hungia striata Walcott.
Hungia flagricauda (White).
Ptychostegium amplum Walcott.
Ptychostegium robsonensis Walcott.
Ptychostegium robsonensis valaltum Walcott.
Ptychostegium canadensis Walcott.
Ptychostegium spinosum Walcott.
Symphysurina spicata augusta Walcott.
Symphysurina canadensis Walcott.
Symphysurina lynxensis Walcott.
Symphysurina spicata major Walcott.
Symphysurina numitor Walcott.
Symphysurina perola Walcott.
Symphysurina spicata Walcott.

Walcott (1928, p. 359) lists some which are not on the above list, as follows:

Acrotreta atticus Walcott.
Eoorthis putillus Meek.
Billingsella archias Walcott.
Walcottanus (?) monsensis (Walcott).
Endoceras robsonensis Walcott.
Kainella billingsi Walcott.
Xenostegium taurus Walcott.

The following additional species have since appeared in the literature:

Lingulella remus Walcott.
Obolus difficilis Ulrich and Cooper.
Schizambon discoidea (Walcott).
Moxomia angulata (Hall and Whitfield).

Burling (1923, pp. 723 and 734) announced the discovery, in the top of Rearguard (later Iyatunga Walcott), of the thin-bedded series of Ordovician shales and interformational conglomerates of which Walcott had found (locality 61q) an isolated portion in The Extinguisher. The strata are in observable contact along a plane of some disconformity with the underlying Lynx, but are cut off by erosion 375 feet above the base of the Chushina. The field section is published in abbreviated form by Walcott (1928, pp. 366-367) who located the *Kainella* fauna in locality 17:130 of bed. 29. His field notes are not available to the author but the section was measured while climbing and bed 29 must be the top. The contact between Lynx and Chushina is now placed at the bottom of bed 28 (bed 1b of his version) where massive cliff-forming limestones gave way to thin-bedded limestones, shale, and interformational conglomerates; he puts it 600 feet below this and 800 feet below the Kainella fauna. Since by definition (1928, p. 356) he placed the Chushina fauna of The Extinguisher (61q) immediately above the Lynx, the Chushina gains an additional 800 feet at the expense of the Lynx by this drawing of the line. He recognizes that this increases the thickness of the Chushina (to 2,300 feet) by stating that the estimated thickness of 1,500 feet is probably too small. But he saw the fossils from bed 27 of my section (the cliff at the top of my Lynx), recorded *Apatocephalus* from it, and evidently considered it definitive of the *Hungia* fauna.

In 1928 (**Walcott**, p. 226) the "locality" of 1923 (see the fourth paragraph under Chushina) is made the type locality of the Chushina, but the lithology of the strata is

changed to read: "hard, dark-gray limestones in thick layers that break down into thin layers on weathering. Interbedded bands of calcareous shale occur at several horizons." The *Hungia* fauna of locality 61q is called the *Kainella* fauna and it is said to occur also "on the summit of Iyatunga Mountain, hence the Chushina is equivalent to a portion of the Mons." "The base of the Chushina," he says, "is clearly defined on Iyatunga Mountain, but the upper boundary is arbitrarily assumed to be 1,500 feet above, although it has not yet been worked out either stratigraphically or by paleontologic evidence."

On a previous page (225) he described the typical Mons as presumably extending north of the Glacier Lake area "where is disappears or merges into the Chushina formation towards the Robson Peak district."

Raymond (1930a, p. 294), speaking of the correlation of the fauna discovered in The Palisade by E. M. Kindle and described by C. H. Kindle (1929) with the Mons of the Glacier Lake area and the Chushina of the Robson district, says that although Robson district is nearer to The Palisade it is probably better to apply the Glacier-Lake name Mons to the formation as developed in Jasper Park. He suggests that the name Mons will ultimately replace Chushina as a formational name. (See Boundaries: Cambro-Ordovician.)

The fauna of locality 61q, has been called:
Basal Ordovician (Walcott, 1913b, p. 336),
Lower Ozarkian (Walcott, 1923),
Ozarkian (Walcott, 1924b, p. 37, and 1928, p. 358),
Basal Canadian (Ruedemann, 1930, p. 311), "The occurrence of *Dictyonema flabelliforme anglica* in the Chushina suggests that this part of the supposed Ozarkian is at the Cambro-Ordovician boundary."
Upper Ozarkian (Ulrich and Cooper, 1938).

CHUSHINA GLACIER

Applied by Walcott (1913b, p. 333 and pl. 57, fig. 2) to a glacier that rests on the northwest slope, and reaches the very top, of Lynx Mountain. (This mountain is labelled Phillips Mountain in the photograph.)

CHUSHINA MOUNTAIN, see Phillips Mountain and Lynx Mountain.

DIKELLOCEPHALUS FAUNA, see Chushina, Raymond 1930b, and Sabine.

EDITH CAVELL (MOUNT), see Cavell quartzite.

EXTINGUISHER, THE

The dark extinguisher-like promontory which rises some 300 feet above the right edge of the Robson Glacier, was called The Extinguisher by Wheeler. Walcott (1913b, p. 331, pls. 57 and 58) called it Billings Butte, and announced the discovery in it of two faunas: an upper (61n) and a lower (61q), with an impressive array of species, which has been the basis of the creation of the Chushina formation.

The line between Lynx and Chushina occurs (Burling, 1923, p. 738) at the top of the cliff about half way up in the section exposed in The Extinguisher.

FITZHUGH, see Miette formation.

FITZWILLIAM, MOUNT

Has banded cliffs of Cambrian rising high above a base of Miette sandstones (Walcott, 1913b, p. 340).

FRANCONIA ZONE, see Roche Miette, Raymond, 1930a.

FRASER RIVER VALLEY

McEvay (1900, pp. 34-35D): "As far down as the Grank Fork the Fraser follows the strike of the rocks along an anticlinal fold, the rocks on the south side dipping away from the valley at low angles, while the dips on the north are much steeper in the opposite direction . . . From Grand Fork to within 4 miles of Tête Jaune Cache the river cuts across the strike almost at right angles, exposing a great thickness of highly altered schistose rocks that appear in all cases to have been originally arkose. The lowest rocks in the series are seen about Swift-current River. Below that point there is an anticline followed by an ascending series for four miles and then a synclinal fold bringing up the beds again so that those seen at Tête Jaune Cache are not very far above the horizon of the beds at Swift-current River."

Especially interesting is McEvoy's statement that the lowest rocks in the series were seen about Swift-current River. The notes on the Fraser Valley have been incorporated because of the help they may be able to give to the geologist who tries to solve the pre-Cambrian problem. See Yellowhead Mountain, Mount Mowatt, Moose Lake Station, Little Grizzly Mountain, and Selwyn Range for the mountains described by McEvoy.)

HENRY HOUSE and SWIFT'S RANCH, see Palisade.

HITKA FORMATION AND HITKA MOUNTAIN

Walcott (1913b, p. 338, pl. 57) gives the name to a high ridge rising above the left bank of the Smoky River north of Mumm Peak. The unfossiliferous Hitka formation was said to form its high slopes. Beneath a very fortunate capping of basal Lynx the mountain was found (Burling, 1923, p. 740) to expose Titkana above Tatei. Abundant fossils confirm the identity of Titkana and Hitka. Walcott (1928, p. 354) says: "From my observations in 1913, I knew that there was duplication and that too great thickness had been given to the section between the Tatei and the Lynx."

HOTA CLIFF

Hota Cliff was named by Walcott (1913b, p. 333) "for cliffs on the southwest slope of Mahto Mountain above Coleman Brook." In plate 57, fig. 1, of the same reference it is shown, however, as a hill between Coleman Brook and Calumet Creek. The exposures were found to be unfossilererous by Walcott, and the contacts with the overlying Chetang and the underlying Mahto are covered. Moreover, the description of the rock in Hota cliffs bears no resemblance to that of the rocks occupying the corresponding stratigraphic position in Mumm Peak, where the upper and lower contacts and every part of the formation is exposed.

HOTA FORMATION

Hota was proposed by Walcott (1913b, pp. 335 and 338) for "gray arenaceous limestones and siliceous shales alternating with massive quartzitic sandstones" (p. 335) and for "massive-bedded arenaceous limestone in great bands of light and dark

gray color with a band of gray, pinkish, weathering limestone at the top that forms the south slope of the ridge on the north side of Coleman Brook and the southwest spur of Mahto Mountain" (p. 338). The latter is the definition which is repeated in 1928 (Walcott, p. 362).

The base of the Hota formation is to be found in the northeastern face of Mahto Mountain. The measured section of massive bedded arenaceous limestone went over Mahto Mountain and "down the west-northwest spur of the mountain to Coleman Brook" (Walcott, 1928, p. 353).

Fragments of *Olenellus* were found (1913b, p. 338) at locality 61s, near the top of the Hota, and at 61t, 300 feet lower in the Hota; and a profuse assemblage containing three distinct Olenellid genera (locality 61k) from beneath the north face of Mumm Peak, just above the Mural Glacier, was also referred to the Hota. This is the "new Lower Cambrian subfauna" of Walcott (1913a) which has been described (Burling, 1923, pp. 741-743) as occurring not above the Mahto, as stated by Walcott, but beneath that formation, in the Mural, and therefore nearly 1,700 feet lower in the section. The Hota contains, therefore, only the fragmentary Olenellids of localities 61s and 61t. This simplifies our problem; we have only to equate clastics with *Olenellus canadensis* fragments (Mount-Mahto Hota) and limestones with a Middle Cambrian fauna (Mumm-Peak Hota).

Walcott (1928, p. 253) compared the Hota and the Mount Whyte, and a lone species of *Olenellus (canadensis)* seems to persist into the Middle Cambrian in some outcrops of both the Mount Whyte and the Hota in their widely separated regions. In the Canadian Pacific Railway region the confusion has been almost baffling. In the Mount Robson region the Mahto-Mountain Hota is Lower Cambrian to the very top and the Mumm-Peak Hota is Middle Cambrian from top to bottom. Even though they have equivalent succeeding Chetangs and equivalent preceding Mahtos, the most natural solution was to give them different names, and this was done (Burling, 1923, pp. 741-743) by applying the name Adolphus to the Mumm-Peak Hota. (See Adolphus limestone and Boundaries: Lower and Middle Cambrian.)

HUNGAIA or HUNGIA ZONE (now Kainella), see Mons formation.

HUTAM MOUNTAIN

West of McEvoy Mountain (Walcott, 1913b, pp. 333 and 340), and 2.75 miles west-northwest of Yellowhead Pass, "Hutam mountain forms an outlying butte of Cambrian sandstone and limestone." Walcott (1928, p. 363) calls this mountain Hota.

IYATUNGA MOUNTAIN (9,000 feet)

Rearguard was named by Coleman and confirmed by Wheeler (1912, p. 36 and map), but the Geographic Board has approved Walcott's substitute. It was described as one of the two mountains best exposing the Middle Cambrian Titkana, but examination showed (in Iyatunga) 3,765 feet of Upper Cambrian Lynx capped by 275 feet of Ordovician with the fauna (61q) of The Extinguisher, which has been placed in the Chushina formation. The line between the Upper Cambrian and the Ordovician occurs (Burling, 1923, p. 738) about half way up in the beds of The Extinguisher and in those forming the top of Iyatunga Mountain. An abbreviated section of the rocks in the mountain has been published (Walcott, 1928, pp. 366-367).

JASPER SERIES

Proposed by Allan, Warren, and Rutherford (1932, p. 231) for rocks presumably of pre-Cambrian age, which "are thrust over the Devonian and Carboniferous Minnewanka limestones of The Palisade section, and form the base of Pyramid Mountain" . . . Where exposed near Jasper it consists "of gray to buff-colored quartzites, argillites, sedimentary breccias, slates and many conglomerate beds. The thickness . . . probably amounts to several thousand feet. It is overlain by quartzites believed to be Lower Cambrian in age. Judging by its lithological characteristics, the Jasper series is quite distinct from the Miette sandstones . . . The relationship of each series with the Lower Cambrian appears to be identical.

KAINELLA ZONE, see Mons, Lynx and Chushina formations.

LAKE KINNEY STATION (6,849 feet)

Lower Cambrian quartzites (Walcott, 1928, fi. 33, p. 350), resting on pre-Cambrian Miette, dip steeply below Mount Robson. It is called Wakpa Point (in the section) and Wapta Point (in the legend).

LITTLE GRIZZLY MOUNTAIN

McEvoy (1900, p. 34D) describes this mountain (calling it the mountain between Grand Fork and Swift-current River) as "composed of greenish and gray schists with fine-grained schistose conglomerate near the bottom, the latter in beds six feet thick. Toward the summit there are black argillites in great thickness with thick beds of gray talcose schist, dark flaggy limestone, and slightly schistose conglomerate. Specimen 86 from the top of this mountain was taken from a part of the conglomerate where the pebbles are smaller than usual. A slide (is described) by Dr. Barlow as . . . a rather typical arkose . . . The base of Robson Peak is probably composed of such arkosic rocks."

Walcott (1927, p. 172) speaks of the mountain as made up of Proterozoic Beltian sandstones and shales. He (1928, fig. 34, p. 351) sketches the cliffs of Little Grizzly Peak with pre-Cambrian Miette and Lower Cambrian sandstones dipping 60° northeast under Lake Kinney and Mount Robson. In plate 106, the same cliffs are called "Skuya Point (7,330 feet)=Robson West Station of Wheeler map."

LOCALITY 61k, see Adolphus, Hota, Mural and Tah.

LOCALITY 61q, see Chushina, Lynx, Mons, and Robson; and Boundaries, Cambro-Ordovician.

LYNX FORMATION

The section above the Titkana (**Walcott**, 1913b, p. 330) "begins on the south slope of Titkana Peak near Snowbird Pass, and extends over Phillips Mountain" [this is Lynx Mountain] . . . The formation is described (p. 337) as "thin-bedded bluish-gray limestone with interbedded bands of light-gray shale, and at the base a band of about 200 feet in thickness of gray, greenish, and reddish brown shale;" and (Walcott, 1928, p. 245) as including beds "with mud cracks and ripple marks that appear to represent the Arctomys." The upper boundary is drawn below beds in The Extinguisher with the fauna of Locality 61q.

He says (1928, p. 356): "For the estimated 2,100 feet of thin-bedded limestone and shale above the Titkana, the name Lynx was proposed . . . and arbitrarily placed in the Upper Cambrian." Later (page 360) he describes the finding of fossils at two localities in the Lynx formation: 61y, about 500 feet below the *Kainella* faunule (61q) of the overlying Chushina; and 61z, about 900 feet below the same faunule. A horizon 500 feet below 61q would be within the Chushina of the Iyatunga Mountain section as he interprets it (p. 367), but the horizon 900 feet below falls within 1a of the Lynx formation in the same section.

Burling (1923, pp. 723 and 736-738) discovered that Mount Rearguard was not Middle Cambrian but exposed a section at least in part additional to that of the Upper Cambrian in Lynx Mountain. Examination of the basal beds of the Lynx on the south-sloping summit of Titkana Peak also disclosed the presence there of the ripple marks, mud cracks, and salt-pseudomorph beds which (as the Arctomys formations in the Canadian Pacific and other southern sections) so often mark the Middle-Upper Cambrian boundary.

In Lynx Mountain, which, as "Phillips Mountain," was called the type locality of the Lynx, there was measured (Burling, 1923, p. 737) a continuous section of 2,685 feet of beds belonging to the Lynx formation. In Iyatunga Mountain there was also found an unbroken section from 375 feet of Chushina downward for 3,785 feet (Walcott, 1928, pp. 366-367).

If the 2,685 and 3,785 figures are added together there is a total of 6,470 feet for the Lynx. Such a total seems large, but, even though there are ten fossil horizons in the upper part of the Lynx-Mountain Lynx, no faunule tie between the two sections was made, and the only known relation is this—that the basal 540 feet of salt-hoppery beds were not seen in Iyatunga. Adding 540 feet to 3,785 gives a minimum of 4,225 feet for undoubted Lynx. This obvious computation was not made in 1923 and the thickness was estimated to be 5,000 feet.

In 1928 **Walcott** (p. 360, footnote) adds 1,400 feet to his first figure for the thickness of the Lynx, making it 3,500 feet, and this figure is used in the summary statement of page 364. He obtained this, he says (p. 366) by adding "500 feet to this part of the section as an estimate for the shaly and arenaceous beds at the base of the Lynx in the Titkana Peak and Chushina Ridge [Lynx Mountain] section of the Upper Cambrian that are not exposed in the Iyatunga section." He thus assumes a tie between the Lynx Mountain and Iyatunga sections that has the Lynx Mountain section overlapped at 500 feet by the Iyatunga Mountain section. With his assumed figure of 500 feet, the one based upon unduplicated shallow-water strata, is in agreement.

The limestones forming the upper part of the Lynx in Iyatunga Mountain are cliff-forming, and the line between the Upper Cambrian and the Ordovician is drawn between them and an overlying series of shales and thin-bedded limestones which, 100 feet above the base, carry the Ordovician *Kainella* fauna. The line occurs about half way up in the section exposed in The Extinguisher and in the top of Iyatunga Mountain.

In 1923 the line between the Upper Cambrian and the Ordovician was drawn at the bottom of bed 1c of the Iyatunga section (Walcott, 1928, p. 367); this made the Ordovician 375 feet thick (Burling, 1923, p. 723). It now seems to the author that this line should be drawn at the base of the thin-bedded greenish shales of bed 1b, with its interbedded shales, limestones, and interformational conglomerates. This makes the Ordovician 275 feet thick, and leaves 3,765 feet of Lynx in the Iyatunga section.

Walcott includes only 2,965 feet of the Iyatunga section in the Lynx, placing 875 feet in the Chushina. This puts the *Kainella* fauna (61q) 800 feet above the base of the Chushina. But he provided for this possibility in his definition of the formation (**Walcott**, 1923, p. 458).

LYNX MOUNTAIN

Nowhere, apparently, in Walcott's two papers (1913b and 1928) on the Mount Robson district (with two exceptions—plate 107 and page 368), is the name Lynx Mountain correctly used. Plate 107 may have a correct legend, and page 368 discusses the Lynx Mountain of Burling's section, which was made in Lynx Mountain. The mountain has been variously called Phillips (1913b), Chushina Mountain (1928, pl. 105), and Chushina Ridge (1928, p. 355), yet it is Lynx Mountain itself and typically exposes the lower part of the Lynx formation. The error of giving a new name to it and of reducing its elevation from 10,471 feet to 9,542 in one and 9,561 in another, was pointed out in 1923 (Burling, pp. 733 and 734). (See Phillips Mountain.)

The mountain to which Walcott applies the name Lynx in the same publications is an unnamed lower mountain whose summit is half a mile southwest of Lynx Mountain, on the skyline between that mountain and Mount Resplendent.

North and Henderson (1954, p. 63) say that the "Ottertail formation is the Canadian Cordilleran representative of one of the continent's great carbonate bodies" . . . It is "known as the Lynx formation in Mount Robson Park" and "it includes beds at the top and base which are younger and older, respectively, than the Ottertail formation . . . The Ottertail . . . probably approaches 4,000 feet in thickness on Mount Robson and neighboring peaks" and "it is marked by a general thinning southward toward Montania."

McEVOY MOUNTAIN

Proposed by Walcott (1913b, p. 332) for Wheeler's Mount Toot-toot, a mountain six miles north-northwest of Yellowhead Pass. The Cambrian rises (p. 340) in it as castellated masses.

McNAUGHTON SANDSTONES AND McNAUGHTON MOUNTAINS

Described, for the McNaughton Mountains (Walcott, 1913b, pp. 335 and 339), as light gray, massive-bedded quartzitic sandstones, 500 feet or more in thickness, without fossils. Only a few layers occur at Moose Pass below the Tah. It is very difficult to determine the line of demarcation between these sandstones of Lower Cambrian age and the pre-Cambrian Miette. Quartzitic beds, some 400 feet in thickness, below the Mural limestone at the north base of the Mumm Peak section (Burling, 1923, pp. 726 and 747) were neither correlated with the McNaughton sandstones nor named. The type locality is given as Moose Pass and the McNaughton Mountains twenty miles away. (See Cavell quartzite.)

MAHTO MOUNTAIN AND MAHTO FORMATION

Proposed by Walcott (1913b, p. 333, pls. 55 and 56) for the "ridge between Smoky River and Calumet Creek." The photographs show it as between Coleman Brook and Calumet Creek. In it the Mahto sandstones are typically developed, but the lower

boundary of that formation is to be found in the northeast face of Tah Peak to the northeast. The upper part of Mahto Mountain and its west-northwest spur expose rocks for which the name Hota has been used.

The Mahto formation (Walcott, 1913b, p. 335 and 1928, p. 362) has been described as massive-bedded, gray, quartzitic sandstones with thin-bedded hard sandstones and dirty-gray brown arenaceous shale in thin beds, 1,800 (est.) feet thick in Tah Mountain and (typically) in Mahto Mountain. It has been described as carrying *Olenellus* (Walcott, 1913b, p. 335); as having no visible fossils (Idem, p. 339); and, finally and emphatically, as having no fossils (Walcott, 1928, p. 253, footnote).

Walcott (1928, p. 256) says "it is possible that the high ridge northwest of Calumet Creek and northeast of Smoky River is formed of the Tah, Mahto, and higher formations."

MALIGNE RIVER, see Medicine Lake for Cambrian rocks on mountain slope east.

MEDICINE LAKE TRAIL, Cambrian in

E. M. Kindle's (1929a, pp. 183-184) section is as follows: "A section across the mountain from the Jacques Lake trail to the Medicine Lake trail starting near Beaver Lake and including Carboniferous rocks south of the junction of the two trails, showed, on the mountain slope east of Maligne River," the following section:

"*Sarceen Series* [Lower Ordovician]:

1.	Drab sandy fine-textured rock with laminae of paper thinness	60 Feet
2.	Light colored quartzite	5 "
3.	Light colored magnesian limestone lower third crushed by thrust fault, apparently grading to quartzite	180 "
4.	Grey mostly thin bedded limestone with occasional heavy beds of quartzite interpolated	200 "
5.	Heavy bedded light colored magnesian limestone. No fossils found	75 "

Devonian (Minnewanka limestone)."

MIETTE FORMATION AND MIETTE RIVER

McEvoy (1900, p. 77A): The course of the Miette River, which flows from Yellowhead Pass to the Athabasca 5 miles above the mouth of the Maligne, follows approximately the summit of a broken anticlinal fold in conglomerates, coarse quartzitic sandstones, and schists, which are brought into contact with the westernmost outcrops of Devono-Carboniferous limestones along a fault three-fourths of a mile above Henry House.

Walcott (1928, p. 258) says that the Miette River cuts through the Miette sandstones and shales east of Yellowhead Pass. Its distribution will probably extend "down Fraser as far as Grand Fork and north to Lake Kinney."

The formation name was proposed by Walcott (1913b, pp. 335 and 340) for massive-bedded gray sandstones with thick interbedded bands of gray and greenish siliceous shales. They are unfossiliferous, and are estimated to be 2,000 or more feet thick. There is an unconformity (Walcott, 1928, p. 363) between the Miette and the overlying McNaughton sandstones, and, while "some of the layers of sandstone are clean and fresh, most of the rock suggests deposition of the sand in muddy water. It may be that more than one formation occurs in the Beltian, but without detailed study and mapping it will be difficult to determine the limits to be assigned to the strata provisionally grouped in the Miette formation."

"The best exposures are along both sides of Yellowhead Pass from the vicinity of Grant Brook on the west to Fitzhugh on the east. They occur as round wooded ridges that rise over 2,500 feet above the Pass . . . To the south of the Pass the banded cliffs of Cambrian rocks in Mount Fitzwilliam and Mount Pelee rise high above their bases of Miette sandstones." (See Jasper series.)

MONS FORMATION

Mons formation was a name proposed for earliest Ordovician in the Glacier Lake area 100 miles southeast of Mount Robson (Walcott, 1923, p. 459). Defined for a series of rocks whose fossils differed just enough from those usual to the Upper Cambrian to suggest the creation of the Ozarkian to receive them, it proved the wideness of its applicability by being adopted for early Ordovician in the Beaverfoot-Brisco-Stanford Range, westernmost of the mountains east of the Rocky Mountain trench and south of the Kicking Horse Pass section (Walcott, 1924b, pp. 16-20 and 22-24). It is now being used in papers on the lower Ordovician of the Jasper Park and Mount Robson districts. In each of the general regions far to the southeast, four faunal zones characterize the formation: the *Ozarkispira leo* zone at the top, preceded in turn by the *Hungaia* (now *Kainella*), the *Symphysurina,* and the *Briscoia* zones.

Near Mount Robson the *Hungia* (new spelling) zone was found in The Extinguisher (locality 61q) by Walcott (1923, pp. 473-474) and in the summit of Iyatunga Mountain (Burling, 1923, p. 734), both in the Chushina formation. This is the reason for calling the Chushina Ordovician. Walcott listed the fauna, which includes six species of *Hungia,* including the type (*billingsi*). (See Chushina formation.)

In 1925, Walcott (p. 102) changed *Hungia billingsi* to *Kainella billingsi,* and in 1928 (pp. 226 and 360) he changed the name of the zone to *Kainella* zone.

C. H. Kindle (1929, pp. 145-147) studied the fossils collected by E. M. Kindle in The Palisade section, and correlated the fossils of bed 4 of his section with a fauna which, in the Beaverfoot-Brisco-Stanford range, is called the *Symphysurina,* and is therefore below the *Kainella.*

Raymond (1930a) has a lower Ordovician Mons dolomite, 800 feet, in Roche Miette.

MOOSE LAKE STATION (7,098 feet)

In the valley of the Fraser (McEvoy, 1900, p. 33D), and "a mile and a half below the outlet of Moose Lake, the slope of Rainbow Mountains, although not affording a continuous section, shows near the bottom a considerable thickness of black and gray argillites followed by gray quartzite and smooth greenish slate and beyond this, after a wide break in the section, a thickness of at least 500 feet of coarse quartzites, followed by 1,200 feet of black argillite to the summit (Moose Lake Station) . . . To the north of the summit across a valley thick beds of dark-colored rock are seen, overlain by dark and yellow-banded rocks looking like those seen on . . . (Mount Mowatt). The appearance of these rocks beyond the summit makes it seem probable that those seen on the slope of Moose Lake Station are of Middle Cambrian age, the coarser quartzites perhaps representing the conglomerates seen elsewhere in that series."

MOOSE PASS (6,700 feet)

Walcott (1927, p. 172) describes the Moose Pass fault between the overthrust Lower Cambrian to the southwest (in Tah Peak) and the Upper Cambrian of the Tokana Mountains to the northeast, as extending "from Moose Pass southeast down the canyon

of Moose River and northwest towards and into the high broken ridge northeast of the Smoky River Canyon." The fault (Walcott, 1913b, pl. 55, figs. 1 and 2, and pl. 56, fig. 1) has a throw of about 9,000 feet.

MOUNT WHYTE FORMATION, see Hota formation, and Boundaries: Lower and Middle Cambrian.

MOUNTAIN PARK AND VICINITY

de Wit and McLaren (1950, pp. 31 and 34-35) find "at Prospect Mountain," in "beds of undetermined age, in part Ghost River," a section of "olive-grey shales, thin-platy to foliated (2 feet); . . . ochre-weathering dolomites (1.5 feet); and olive-grey-friable shales in bands 3 to 5 feet thick alternating with harder bands 5 feet or more thick of light brown, platy, thin-bedded siltstone and containing scattered layers of edgewise conglomerate, ½ foot thick [whose] pebbles are grey limestone pellets . . . (106.5 feet)." Though they do not say so, these suggest contemporaneity with the basal portion of their Roche Miette section.

MOWATT (MOUNT)

McEvoy (1900, p. 78A) says: "Fourteen miles from Yellowhead Pass a large stream called Grant Brook flows in from the north . . . A mountain on the west side of this stream (Idem, p. 32D) gave no exposures for the first 2,000 feet, where gray quartzites dipping 70°N 25°E "in beds two to three feet thick, with slaty partings, continue . . . for 2,000 feet." The section in ascending order shows 1,200 feet of limestones and slates, 1,200 feet of gray quartzites like those at the base of the section, and 3,000 feet of limestones (p. 33D) "dark-blue and yellowish-weathering, alternating with banded gray and yellow schists." The rocks "correspond well with those of the Castle Mountain group. The quartzites at the bottom, which are undoubtedly the same horizon as those seen in Yellowhead Mountain, appear here to belong also to the Castle Mountain."

MUMM PEAK (9,740 feet) AND MUMM LIMESTONE

Mumm Peak is directly north of Mount Robson, on the north side of Robson Pass, and is described by Walcott (1913b, pp. 337 and 339) as exposing the Hota and the Mumm, and, therefore, also the intervening Chetang, Tatei and Hitka formations. Actually, the so-called "Hota," forming the cliff just above the Mural Glacier (Walcott, 1913b, pl. 59, fig. 1), is the Tah, and the top of the mountain exposes the Chetang (Burling, 1923, p. 733). The succession in Mumm Peak is, therefore, not (reading from the base upward) Hota, Chetang, Tatei, Hitka, and Mumm, but Tah, Mahto, Hota, and Chetang.

The limestone, found by Walcott at the base of the Titkana Mountain section, below the Titkana, and named Mumm from its supposed occurrence in the upper part of Mumm Peak, is actually an exposure of the Tatei formation. The cliff below a capping of Chetang in the top of Mumm Peak is, by definition, Hota, but it is Middle Cambrian to the very bottom, and the Hota is defined as carrying *Olenellus*. (See Hota and Adolphus.)

MURAL LIMESTONE

In 1915 it was discovered (Burling, 1923, pp. 744-746) that the cliff in the base of Mumm Peak above the Mural Glacier (Walcott, 1913a, pp. 309-310) with its "new Lower

Cambrian subfauna" was neither Mahto (the localities of 1913a) nor Hota (Walcott, 1913b, p. 339). The cliff proved to occupy the stratigraphic position of the Tah formation, below a thousand feet of Mahto sandstones. It was thought unwise to assign to the Tah a formational unit so different (in lithology and fauna) as the Mural-glacier cliff, and the name Mural was proposed for the facies of the Tah which had yielded so rich a Lower Cambrian fauna. (The fauna list of Locality 61k will be found under Tah.) (See Cavell quartzites, North and Henderson.)

OLENELLUS-BONNIA ZONE

This is an assemblage of uppermost Lower Cambrian fossils very frequently marking a single bed (often thin) which is transitional upward from clastic to calcareous in the Canadian Pacific Railway section. Above this bed *Olenellus* occasionally does occur, but nearly always in fragmentary form, and these instances are believed to represent the survival, in particular environments within the earliest Middle Cambrian seas, of a disappearing biota.

Finding it deep in the Mahto instead of at the top, is unusual, but the presence of limestones in the position of the Tah and the Mural is itself strange, speaking from the standpoint of the sections 150 miles to the southeast. (See Boundaries: Lower and Middle Cambrian.)

OLENELLUS FAUNA, see Boundaries, Lower to Middle Cambrian; Mural limestone.

OZARKIAN, see Mons and Sarceen.

PALISADE (THE)

McEvoy (1900, pp. 30-31D) discusses an ascending section seen between a point two miles north of Snaring River and Henry House, with possibly a fault at Snaring River. On the north side of Snaring River he found 5,000 feet of limestones, probably Devonian; on the south side 800 feet of quartzite, shales, and gray limestone, overlain, at Swifts, by 700 feet of dolomite. "Three-quarters of a mile above Henry House (Idem, p. 77A) the Devono-Carboniferous limestones are cut off by a fault . . . and no trace of them was found on the route west of this." West of the fault there are exposures of hard fine-grained conglomerates or coarse quarzitic sandstones closely resembling the Bow River series.

E. M. Kindle (1929a, pp. 181 and 186) describes the section in The Palisade and says that the rocks "above the basal 400 feet are accessible only along . . . a brook which reaches the Athabasca 7 miles north of Jasper at Swift's Ranch, where covered intervals prevent complete examination." His assembled section follows:

1.	Gray Shale and limestone (*Carboniferous*)	500 Feet
2.	Gray to blue limestone, lower half magnesian (*Devonian*)	2,500 "
	Sarceen (Mons; Ulrich's Ozarkian):	
3.	Olive-gray shale with magnesian limestone interpolated	140 "
	Covered	200 "
4.	Thin-bedded subcrystalline limestone, no lamination, with a *Symphysurina* fauna	10 "
	Upper Cambrian:	
5.	Hard, laminated limestone, interbedded with shaly bands and beds of magnesian limestone	250 "

6. Hard, semi-lithographic limestone in bands a few feet thick separated by bands of dark shaly limestone ---------- ±200 "

E. M. Kindle (1929a, p. 186): The *Symphysurina* fauna immediately follows a fine lamination which is regarded as a special facies of Upper Cambrian sedimentation, and is itself regarded as a special biota segregated from the ordinary Upper Cambrian fauna and specialized by special conditions. The fine lamination of the oldest beds is disclosed by weathering and the rock has a vaughanite limestone-like texture. The lamination is compared to varves, probably tidal, in lagoons unfavorable to marine life. Divisions 4 and 5 appear to represent Mons. The only fossils in the lower 800 feet occur in 4, but 3 is believed also to be Sarceen.

C. H. Kindle (1929) describes a fauna of eight species from bed 4 of E. M. Kindle's section, which is exposed in the brook near the old mill at Swift's Ranch. Of the following list the first two are the most common: *Eoorthis ochus* Walcott, *Raphistoma* sp. undt., *Eoorthis ochus concentricus* Kindle, *Huenella jasperensis* Kindle, *Syntrophia convexa* Kindle, *Tostonia* cf. *iole* Walcott, *Hardyia metion* Walcott, and *Symphysurina walcotti* Kindle. He suggests correlation with locality 16u, a *Symphysurina* fauna above a *Briscoia* faunule in the Mons of Walcott's Sinclair Canyon section (1924b, p. 19).

Raymond (1930a, p. 289) describes The Palisade Cambrian outcrop as the middle one of three bands of Cambrian in the Jasper Park region. As a yellow band it "appears in Mount Chetamon, crosses the Snaring River and extends for some distance along the base of The Palisade."

He (p. 294) cites C. H. Kindle's correlation of The Palisade with Walcott's locality 16u, and says: "The fauna of 16u is the very oldest one in the Mons, occurring in a bed about 200 feet above the strata in the Sabine which contains *Briscoia.*" As a matter of fact, the fauna of 16u is "a strongly-marked *Symphysurina* faunule" (Walcott's words in 1924b, p. 19) and it occurs 200 feet above the *Briscoia* fauna in the Sinclair Canyon Mons. Raymond continues: "The Palisade fauna can, therefore, be correlated with the Mons of the Windermere and Glacier Lake areas, and with the Chushina of the Robson district. Although the latter region is the nearer it is probably better to apply the name Mons to the formation as developed in Jasper Park since the name will probably ultimately be applied to the strata now called Chushina."

Allan, Warren, and Rutherford (1932, p. 233) repeat Kindle's section and say: "This fauna, which may be correlated with the Mons of the Windermere and Glacier Lake area, is included by Kindle in the Ozarkian of Ulrich. It would undoubtedly be termed Ordovician by Swedish geologists. It is so placed by Raymond." In figure 1 of page 227 of their paper they show a thrust fault along the base of The Palisade which thusts Cambrian to the northeast over Carboniferous. Between The Palisade and Pyramid Mountain there is shown a fault thrusting the pre-Cambrian of the latter over the Carboniferous at the top of The Palisade.

For faulting between The Palisade and Pyramid Mountain, see also the latter. (See also Chetamon, Cavell quartzite, and Jasper series.)

PELEE, MOUNT

Has banded cliffs of Cambrian rising high above a base of Miette sandstones (Walcott, 1913b, p. 340).

PHILLIPS MOUNTAIN

Proposed by Walcott (1913b, p. 333) for a mountain with a height of 9,542 feet. The only topographic feature in the vicinity with this height is Lynx Center Station of Wheeler (1912, map) which is on the north arête of Lynx Mountain about half of a mile north of the mountain itself. From this point on the ridge (Wheeler, p. 19) Lynx Mountain abruptly rises 900 feet to its summit at 10,471 feet. Actually, then, Phillips Mountain was proposed, not for a mountain, but for an instrument station on the ridge between Lynx Mountain and Snowbird Pass. It is on the snow-free sky-line between the two glaciers.

But, on the photographs (Walcott, 1913b, pl. 57, fig. 2, and pl. 58, fig. 1) the name Phillips Mountain is given to Lynx Mountain itself, and this mountain is credited with a height of only 9,542 feet.

This will be abundantly clear to anyone who compares Wheeler's (1912, p. 22) photograph, taken from Lynx Centre Station, 900 feet below Lynx Mountain, with Walcott's photograph (1913b, pl. 57, fig. 2) of his Phillips Mountain. Compare particularly the notched cliff above the snow bank at the end of the west shoulder of Wheeler's Lynx and Walcott's Phillips. This was made clear in 1923 (Burling, pp. 733 and 734).

But in 1928 (plate 105) Walcott changes Phillips Mountain (9,542 feet) to Chushina Mountain (9,561 feet); and on page 355 it is renamed Chushina Ridge. If the name Lynx Mountain ever proves to have been used for another Canadian Cordilleran Peak, even Phillips will have precedence over Chushina. Both names, in spite of their being labeled 9,542 and 9,561 feet, respectively, were, by overprinting and by legend, inescapably tied to the real Lynx Mountain (10,471 feet).

Now, this is the mountain which exposes the Lynx formation, and, since it is Lynx Mountain, and not Phillips, the name Lynx may properly be used for the formation. But, since the Lynx formation is at least 4,225 feet thick, it is doubtful if Lynx Mountain, with the Chushina glacier on its northwestern slope, contains any rocks belonging to the Chushina.

Except when quoting from Walcott directly, or when referred to in quote marks, the name Phillips will not be used in this paper. The mountain is Lynx, and it will be so called.

PTARMIGAN PEAK, see Titkana Peak.

PYRAMID MOUNTAIN (9,000 feet)

McEvoy's map (1900) shows a contact between Devono-Carboniferous and Cambrian Castle Mountain, northeast of Pyramid Mountain, with a contact between the Bow River and the Castle Mountain in the stream south of the mountain.

Raymond (1930a, p. 292) describes a great fault between Pyramid Mountain and The Palisade which has brought up, in Pyramid Mountain, pre-Cambrian overlain by Cavell quartzite . . . "mostly of pure quartz sand, in part thinly bedded, with some shaly partings." The exact contact between the pre-Cambrian and Cambrian has not been determined, but the Lower Cambrian appears to be at least 3,000 feet in thickness.

Allan, Warren and Rutherford (1932, fig. 1, p. 227) show a fault between Pyramid Mountain and The Palisade as thrusting the pre-Cambrian Jasper series in the upper part of the former over Carboniferous in the latter.

RAINBOW MOUNTAINS, see Moose Lake Station.

REARGUARD (9,000 feet), see Iyatunga Mountain.

RESPLENDENT (MOUNT) (11,173 feet)

Mount Resplendent was not used as a formation name, nor was a section measured in it, but two of the splendid photographs (Walcott, 1913b, pl. 57, fig. 2, and pl. 58, fig. 2) show the name applied to an unnamed peak. It is this unnamed peak (not Resplendent) which is tied to The Extinguisher by a snow-free ridge during most of the summer. Resplendent is correctly labeled in plates 105 and 108 of Walcott (1928).

ROBSON (MOUNT) (13,068 feet)

McEvoy (1900, p. 34D) describes Mount Robson as follows: "The base of Robson Peak is probably composed of rocks similar to the arkosic rocks in the top of . . . (Little Grizzly Mountain), while the upper portion appears to consist of banded black and yellowish limestone and yellow schists resembling those seen in . . . (Mount Mowatt). If the fine-grained quartzites continue this far westward they should appear between these two series." He maps Mount Robson as Castle Mountain.

Wheeler (1912, p. 40) cites Coleman (Canadian Alpine Jour., vol. 2, No. 2, p. 108) as saying that Mount Robson "as a whole is built of nearly flat-lying limestone resting on quartzite, the latter rock showing only on the south side . . . From a structural point of view, Mount Robson represents the bottom of a syncline or basin, with gentle inclination from all sides." Wheeler publishes a photograph (opposite p. 52) which shows this perfectly.

Close to Mount Robson (**Walcott**, 1928, p. 258 and pl. 97) the inward dips of the Lower Cambrian quartzites range from 10 degrees on the west and northwest to 30 degrees on the south and southwest. In places, as in Wheeler's Robson West Station (7,330 feet) and in Lake Kinney Station of Wheeler (6,849 feet) the dips steepen greatly as the contact with the outlying pre-Cambrian is neared (Idem, pp. 357 and 358).

Portions of the geologic section, visible in the mountain or in photographs have been described as follows:

The west side. The Middle Cambrian limestones extend [from the top of the Lower Cambrian sandstones at the southeast end of Lake Kinney, Walcott, 1928, p. 365] "to the first long talus slope. From here for about 3,000 feet the limestones are of Upper Cambrian age to the top of the low dark cliffs at the foot of the talus slope of the higher portion of the cliffs. Above this, as far as known, the limestones are probably of Upper Cambrian and Lower Ozarkian age" (Walcott, 1928, pl. 95 and p. 349).

The dark band. "Photographs indicate the presence of a dark band that may represent the dark limestones of The Extinguisher with their Lower Ozarkian fauna (61q)" (Idem, p. 366). On page 356 Walcott says that the dark band at the top of Iyatunga Mountain [which is the band that can be seen in The Extinguisher] apparently extends across, although interrupted by the Helmet faults, into Robson Peak about half way up between Berg Lake and the summit of the peak." As Robson Peak is 13,068 feet high, and Berg Lake 5,380, the band crosses into Mount Robson at an elevation of about 9,200 feet, or 2,000 feet below the Helmet and almost exactly level with the top of Iyatunga Mountain at 9,000 feet. Since the base of the Upper Cambrian is at an ele-

vation of 8,200 feet in Mount Robson, there would be room, between this known point and such a dark band, for only about a thousand feet of Upper Cambrian. There is, however, more than 2,000 feet of Upper Cambrian in each of two sections, without discovered duplication. It would seem as if this "dark band" identification, as well as those of "the west side," might be discounted.

Walcott (1913b, p. 331) said that the estimate of 3,000 feet of Ordovician limestones in the summit of Mount Robson was "based on the view obtained from Billings Butte (The Extinguisher) of the Upper Cambrian beds as they extend along the base of Mount Resplendent into Robson." He considered the estimate too low, due, for one thing, to faulting between Mount Robson and Helmet Mountain. Two thousand feet of the 3,000-foot figure have been eliminated by the separation, from the Robson, of a 1,500-foot Ordovician Chushina formation (**Walcott**, 1923, p. 458) and the tentative assignment to the Ordovician, of only the upper 500? feet, which retain the name Robson (Idem, 1928, pp. 356 and 358).

An attempt to identify the rocks at the top of Mount Robson has been made. Walcott (1928, p. 365), using the fact that there had been found (**Burling**, 1923, p. 736) in Mount Robson, and at an elevation of 7,100 feet above sea-level, a Stephen formation faunule, assumed two or three hundred feet as the superjacent thickness of the Middle Cambrian, and obtained a thickness of 5,600 feet between the base of the Upper Cambrian and the top of the mountain. The same easily recognized faunule was, however, located 1,500 feet (instead of two or three hundred feet) below the Upper Cambrian in Titkana Mountain, which puts the base of the Upper Cambrian at an elevation of 8,600 feet in Mount Robson. There is therefore (13,068 feet minus 8,600) room, in the top of Mount Robson, for some 4,475 feet instead of "5,600 feet" of strata above the Middle Cambrian.

Whether there are any beds younger than the Chushina in Mount Robson depends entirely on the thickness of the Lynx and the Chushina. Walcott (1928, p. 360) assigns 3,500 feet to the Lynx, and 2,300 feet to the Chushina (1,500 feet above the fauna of 61q, on pages 358-359; and 800 feet below 61q, on pages 366-367). This total of 5,800 feet so far exceeds the available space of 4,475 feet as to leave no room at all for any of the 1,500 feet of beds assigned to the Robson limestones. But Walcott places the fauna of 61q so low in the Chushina (1,500 feet below the top) that there is somewhat more than enough room for that fauna in Mount Robson.

Burling (1923, p. 723) assigned 5,000 feet to the Lynx formation and 375 feet to Ordovician strata with the fauna of locality 61q, but Walcott (1928, p. 365) suggests quite correctly that failure to find a faunule tie between the separate sections of the Lynx is insufficient evidence for adding them together and getting 5,000 feet for the thickness of the formation. A new appraisal (see Lynx formation) yields 4,225 feet as a minimum for the Lynx and 275 feet for the thickness of known Ordovician. This new total of 4,500 feet practically places the fauna of locality 61q at the top of Mount Robson!, as suggested in 1923 (p. 723).

Since locality 61u, from the Chupo Glacier, has been identified as Chushina, the finding of locality 61q at or near the top of Mount Robson becomes probable.

Views of Mount Robson from different directions are represented by Walcott's photographs (1928): Plates 98 from the north, 96 from the northeast, 99 from the south-southeast, 97 from the south-southwest, 95 from the northwest, and 94 from the north-northwest.

ROBSON LIMESTONES

For the rocks in the upper 3,000 feet of Mount Robson, Walcott (1913b, p. 336) proposed the term Robson limestones. Based on morainic material, the formation was described as "light gray or dove-colored and bluish-gray thin-bedded limestones, forming massive strata on cliff exposures." He continues: "The practically inaccessible upper 1,500-foot portion weathers like the great arenaceous limestones of the Kicking Horse Pass section 150 miles to the south. Large blocks of the arenaceous and dolomitic buff-weathering limestones, also siliceous and calcareous gray shale with buff-weathering magnesian limestone in thin layers were brought down by the central moraine of Robson Glacier."

The type locality is said to be "Robson Park district: Robson Peak and probably east of Moose Pass." The formation is stated (1928, p. 218) to be "of doubtful value; all the strata included in it may belong to the subjacent Chushina."

Walcott (1923, p. 458) defined a new formation (the Chushina) for that part of the 3,000-foot Robson limestones to which The Extinguisher fauna of locality 61q had been credited. The upper boundary of the Chushina was arbitrarily so placed as to include also 1,500 feet of overlying unfossiliferous shales and thin-bedded limestones. For the superjacent 1,500 feet of "massive limestones forming the main mass of the upper portion of Robson Peak" which are "more massive-bedded and arenaceous than the strata below" the name Robson limestones was retained (Walcott, 1913b, p. 336).

In 1928 (Walcott, p. 358) the Robson limestones were further limited by the tentative assignment, to the Ordovician, of an estimated upper 500? feet of "partly siliceous, arenaceous, and dolomitic gray and buff-weathering limestone in layers varying from one inch to 18 inches in thickness" for which the name Robson was retained. Unaccounted for, is the main limestone mass which has been described as directly overlying the shales and thin-bedded limestones of the Chushina (Walcott, 1923, p. 458), and which must therefore underly the newly separated 500? feet of thin-bedded limestones.

No fossils, morainal or otherwise, have been found in the Robson limestones (Walcott, 1928, p. 358). Those listed (Walcott, 1913b, p. 334) came from localities 61q (in The Extinguisher) and 61u (on Chupo Glacier) and are now referred to the Ordovician Chushina.

ROBSON WEST STATION (7,330 feet)

Lower Cambrian quartzites (Walcott, 1928, pl. 106) resting on Miette sandstones, dip steeply under Lake Kinney and Mount Robson. Walcott calls it Skuya Point.

ROCHE MIETTE

McEvoy (1900, pp. 29-30D) describes and figures a section 3,300 feet thick, all of the beds of which appear to be Devonian, "of a horizon lower than those seen in Folding Mountain."

Dowling (1912, p. 206): "The rocks of Roche Miette show a heavy limestone bed of a somewhat yellowish-weathering appearance superimposed on shales and sandy limestones, the lowest of which represent horizons below the Devonian. It is probable that the same heavy limestone is repeated in the cliffs on the west side of Brulé Lake."

Raymond (1912, p. 208), who reported on Dowling's fossils, describes, for Roche Miette, a distinct yellow bed which is (a) near the base of the rock series forming the

mass of the mountain, and (b) near the fault line along which the Paleozoic has been thrust over the Cretaceous. He says: "Along the range to the south, a few hundred feet of lower beds intervene, but this yellow band is very near the base of the limestone series as exposed in the outer ranges."In this yellow band Dowling secured fossils which were identified by Raymond as "lowest Devonian or possibly Silurian." Two hundred feet below this horizon, in the same yellow band, and without "marked unconformity" between, Dowling secured Cambrian fossils which Raymond identifies as follows: *Crepicephalus* cf. *iowensis* (Owen), *Ptychoparia affinis* Walcott, *P.* cf. *wisconsinensis* Owen, *Dicellomus* sp. ind.

"These species indicate a horizon about the same as the upper part of the Gallatin limestone of Montana which Walcott has referred to the upper part of the Middle Cambrian. The fauna is also similar to that of the upper Middle Cambrian of the upper Mississippi valley, and not of the same type as the Middle Cambrian at Mount Stephen and elsewhere."

E. M. Kindle's (1929a, pp. 179-180) section in the Miette Range is as follows: "The oldest rocks known in the eastern part of Jasper Park are well exposed on the northern slopes of Roche Miette, two miles south of Pocahontas. A great thrust fault brings Cambrian into contact with Mesozoic. The section begins about half a mile west of Miette Creek on the western side of the fault, starting in the Cambrian sediments and terminating near the top of the Devonian at the old lime kiln on the east side of Rocky River valley.

Devonian (Minnewanka limestone).

Upper Cambrian (in nine zones):

9.	Thin-bedded, fine-textured, magnesian limestone in strata varying in thickness from a fraction of an inch to one or more feet. Many beds in middle with salt-crystal pseudomorphs, rare ripple marks, and mud cracks. The layers also show on weathered surfaces fine laminae, thin as paper, representing periodic planes of deposition. This limestone is a light gray on fresh surface, but weathers to a brownish buff and at a distance has the appearance of a buffish brown shale. No fossils found	±900 Feet
8.	Dark gray heavy-bedded limestone somewhat saccharoidal in some beds and splitting very easily, on weathering, at right angles to the bedding. Middle beds with worm-tube (?) structure. No fossils seen	±600 "
7.	Covered	±350 "
6.	Heavy-bedded limestone with numerous calcite seams in lower part. Weathers buffish brown; no fossils seen	50 "
5.	Very thin-bedded limestone (layers ¼ inch or less) with paper-thin shale bands between. Carries trilobite fragments	8 "
4.	Green clay shale, soft and altered by crushing	20 "
3.	Limestone, weathering buffish brown	35 "
2.	Covered	75 "
1.	Limestone with bands of oolitic structure	± 65 "

Zones 1-9 are regarded as Upper Cambrian though fragments were too poor for identification.

The Devonian rests upon the Cambrian without evident unconformity. The contact is to be seen a few hundred feet east of the gorge cut by stream which crosses the highway 1⅞ miles west of Pocahontas coal mine."

The Palisade fauna has been referred to the Mons by E. M. Kindle and to the *Symphysurina* zone by C. H. Kindle; the Roche Miette fauna has been referred to the Cambrian by Raymond, who equates The Palisade and Roche Miette faunas.

According to **Raymond** (1930a, pp. 290 and 292-3) the most easterly of three bands of Cambrian rocks in the Jasper Park region lies along the northeastern side of the Miette and Bosche ranges, where the Cambrian is thrust over the Cretaceous. This eastern band can be studied in the northeast shoulder of Roche Miette. The actual contact of Cambrian over Cretaceous was not seen but was located within fifty feet at two localities. In the bed of the most southeastern tributary of Roche Miette Creek it is at an altitude of about 5,700 feet. The Cambrian is best exposed in this vicinity. The folding and dislocation in the lower part of the Cambrian, just above the thrust, and the rapid change in dip, make it difficult to obtain the actual thickness of these strata. Measurements on the profile from the fault to the base of the Devonian show that, with the most favorable dips, there is room for only 1,300 feet of strata. No satisfactory measurements of dip could be obtained in the Cambrian; the dip of the top of the lower member of the Devonian is about 70° S.W.

Raymond gives the following section of the Cambrian, beginning at the top, with estimates of the thickness.

Middle Devonian Flume ---------- 400-1,800 Feet

Lower Ordovician Mons dolomite ---------- 800 "

Upper Cambrian:

Snaring formation

Zone 7. Gray dolomite which weathers a rusty yellow; coarsely granular with much cross-bedding ---------- 150 "

Zone 6. Green and red shale, with a red band containing numerous salt-hoppers at the base ---------- 90 "

Chetamon formation

Zone 5. Yellow, cavernous dolomite with interbedded green shale ---------- 50 "

Zone 4. Shaly blue and gray limestone with abundant trilobites, all small---- 150 "

Middle Cambrian

Bosche formation

Zone 3. Massive dark gray magnesian limestone which forms the cliff that slopes off northwestward toward the road ---------- 200 "

Zone 2. Impure nodular gray limestone with fragments of trilobites ---------- 300 "

Zone 1. Green shale, poorly exposed.

Lower Cambrian

Cavell quartzite ---------- (est.) 3,000 "

Zones 1, 3, 6 and 7 are unfossiliferous. See the formations for discussion of the faunas secured.

The fossils in zone 4 are: *Conaspis* cf. *anatina* Hall, *Conaspis* cf. *pattersoni* Hall, *Taenicephalis* cf. *shumardi* Hall, *Wilburnia* sp. ind., *Acrocephalites* sp. ind., *Lonchocephalus* sp. ind.

Zone 5 has one fossil, probably *Billingsella*.

Raymond compares the fauna of zone 4 (and that of bed No. 4 of the Palisade section) with the fauna of the Franconia in the upper Mississippi Valley as obviously Upper Cambrian, and says that Walcott has shown, in a district north of Lake Louise, that the Franconia is below a *Briscoia*.

Allan, Warren, and Rutherford (1932, p. 232) describe the Cambrian of Roche Miette as being overlain disconformably by the Minnewanka limestone of the Devonian, and give Raymond's 1930a, p. 290, section, minus the three formation names which he used, and without indicating the grouping of the several zones. His list of fossils was, however, given. Figure 1, p. 227, shows Cambrian thrust over Carboniferous.

de Wit and McLaren (1950, pp. 24-25) say that the strata which underlie the Flume formation of the Upper Devonian and overlie the Cambrian correspond approximately with the Ghost River formation of the Bow River. They "failed to find on Roche Miette an indication of a clear break anywhere in the succession" between undoubted Cambrian strata and the base of the Flume . . . "the upper limit of the Cambrian is placed at the uppermost occurrence of olive-green shales . . . The upper part of the Cambrian system consists of: alternating ochre-weathering dolomites; blue limestone beds, with ochre mottling and in part carrying abundant trilobite tests; green shales, and 8-inch conglomerate beds of dolomite with dolomite pellets."

SABINE FORMATION

Here there has been another importation into the literature of the Jasper Park region. The correlation of the Lynx with the Sabine is no more defensible than is the identification, with the Sullivan, of the Lynx, but for a different reason. Raymond (1930b, p. 304) has said: "The equivalent of the Glacier-Lake Mons in the Robson region was called Chushina by Walcott. It rests on the Upper Cambrian Lynx, apparently the equivalent of the Sabine since it yielded *Dikellocephalus* to Burling (Walcott, 1928, p. 367)."

The reason for caution here is that the Sabine is (Idem, p. 342 and footnotes) a formation of singularly doubtful stratigraphic value, even in its nearest outcrops at Glacier Lake some hundred miles away. The Sabine was proposed by Schofield for a formation, in the Upper Columbia Lakes region another hundred miles away, which Walcott (1924b, p. 49) called the equivalent of the Mons, and therefore Ordovician. But Resser (in a footnote to Walcott, 1928, p. 342) expresses doubt whether an Upper Cambrian formation in the Glacier Lake area can be sufficiently representative of an Ordovician formation one hundred miles away to warrant the importation of the name. The same footnotes make the pre-Sabine graptolite-bearing "Lyell" possibly post-Sabine in age! Walcott's importation of the Sabine into the Glacier Lake section, and Raymond's use of the same name, even as a correlation, in the Mount Robson region, are confusing. (See Chushina, Raymond, 1930b.)

SALT-CRYSTAL PSEUDOMORPHS, see Lynx formation; Roche Miette, E. M. Kindle and Raymond, 1930a; and Snaring formation.

SARCEEN SERIES

The name was proposed by Walcott (1923, pp. 471-476) to replace Saratogan as used by Ulrich (1911, pp. 332-333 and 338) and Walcott (1903, pp. 318-319). Walcott calls the Mons of Alberta the type of the Sarceen, and correlates with it the Chushina of the Robson district, at least the part of the Goodsir which is above the Upper Cam-

brian portion, the Red Lion of Montana, the St. Charles of Idaho and Utah, the Notch Peak of Utah, and the Goodwin of Nevada. It is described as Post-Cambrian and pre-Ordovician, or Ozarkian. (See Chushina and Mons; Medicine Lake; Introduction, Kelly; and Palisades.)

SELWYN RANGE

McEvoy (1900, p. 80A) found, in the Selwyn Range, of which he visited four mountains, a section comprising schistose conglomerate overlain by "undulating folds of black argillite and yellow schists, including beds of dark flaggy limestone, yellow, finely crystalline, dolomitic limestone and talc. The former of these probably corresponds with the Bow River series and the latter with the Castle Mountain group."

McEvoy (1900) speaks of the undoubted Cambrian age of the synclinal "first" mountain (northeast of McLennan River), and of a similar sequence in the "second" mountain (northeast of Cranberry Lake). He assigns the lower part of the series to the Bow River and says: "The overlying schists and argillites probably belong to the same series but may include, toward the top, beds of the . . . Castle Mountain group." He maps the Selwyn Range as Bow River.

SIGNAL MOUNTAIN, see Cavell quartzite.

SKUYA POINT (7,330 feet), see Robson West Station.

SMOKY RIVER

One or more faults (Walcott, 1928, p. 354) are evidently present in the canyon valley of the Smoky River between Titkana and Mumm peaks.

SNARING FORMATION AND SNARING RIVER

"The Snaring formation (Raymond, 1930a, p. 291) consists of shaly limestone, shale, and dolomite which sweeps down the southwest shoulder of Mount Chetamon, crosses the Snaring River, and forms the lowest cliff of the Palisade west and northwest of Henry House." These rocks are also spoken of as a "yellow band," and while zone 5 of the Roche Miette section is yellow, Raymond actually says that the yellow band is Snaring (or zones 6 and 7), and the formational thicknesses on page 300 confirm this.

"Along the Snaring," Raymond continues, "about one mile up river from the bridge, Dr. Parejas and Irving Reimann collected trilobites like those found in the Chetamon on Roche Miette. As at the latter place, yellow-weathering unfossiliferous dolomites overlie the shale with trilobites. For the dolomites the name Snaring formation is suggested."

Zones 6 and 7 of Raymond's Roche Miette section are described (Idem, p. 291) as containing "strata deposited under conditions of shallow water with occasional emergence. The pseudomorphs after salt crystals in a red layer at the base have already been referred to by E. M. Kindle [1929a, p. 180] . . . The formation is believed . . . to be of Upper Cambrian age and to be a representative of the Snaring formation.

"The *Briscoia* fauna has not yet been seen in Jasper Park. It may eventually be found in the Snaring formation which seems to be of very shallow-water origin. There is a possibility, however, that the upper part of the Snaring, as developed at Roche Miette, is an eastern equivalent of the Mons. In the section on Iyatunga Moun-

tain and in The Extinguisher the Chushina (Mons) is underlain by the Lynx formation which has *Dikellocephalus* in the upper part. The Snaring is probably a shallow-water near-shore equivalent of the upper part of the Lynx." (See also Palisade, McEvoy.)

SNOWBIRD PASS, see Titkana.

STEPHEN FAUNA

The faunule to which this name was applied in the correlation between a horizon 1,100 feet below the top of the Titkana formation and the same stratigraphic horizon 7,100 feet above sea-level in Mount Robson, and which was used in trying to determine the age of the rocks in the summit of that mountain, was easily recognizable as Stephen, but it did not include the *Ogygopsis* or the Burgess faunas of the Canadian Pacific Railway section.

SULLIVAN FORMATION

Proposed by Walcott (1923, p. 461) for an Upper Cambrian formation in the Glacier Lake region (100 miles southeast of Mount Robson) which occupies a position in the section between Arctomys below and Lyell above. To the Sullivan, Resser (1942, p. 49) referred *Kingstonis robsonensis* of locality 61r, and on page 72 of the same paper, the same drift locality, with *Maryvillia moosensis,* is referred to the Lynx as a Sullivan equivalent. On page 54 (Idem) *Bynumia robsonensis* is also recorded, from localities 191 and 19m, in the Lynx of the Iyatunga section, as "Lynx (Sullivan equivalent)."

Now, the Lynx is the whole Upper Cambrian in Robson Park. Therefore, to accept the Sullivan as its equivalent would mean that the other Upper Cambrian formations at Glacier Lake are additional to the Lynx. The equivalent of the Lynx at Glacier Lake is, as far as we now know, the Arctomys-Sullivan-Lyell-Sabine sequence (naming them in ascending order), not the Sullivan alone. We know that there is, in the Lynx, the equivalent of the Arctomys, and thin beds between its salt-crystal layers which carry graptolites may be our first opportunity to date the period of emergence which marks the apparent boundary between the Middle and Upper Cambrian in so many places. We also know that there are plenty of edgewise conglomerates, ample Lyell-like cliffs, and, above the cliffs, more interformational conglomerates and fossils that show the commingling of Upper Cambrian and Ordovician forms. This also characterizes the Mons-like Sabine. In the Mount Robson region these upper beds are separated as Chushina, but calling the Lynx Sullivan obscures all this.

SWIFT'S RANCH, see Palisade.

SYMPHYSURINA ZONE, see Palisade, Roche Miette, and Mons.

TAH MOUNTAIN (8,817 feet) AND TAH FORMATION

Proposed by Walcott (1913b, p. 334 and pl. 55) for Moose Pass Station of Wheeler (1912, map) southwest of Moose Pass. (See Moose Pass for the faulting.) The Tah formation is (Idem, p. 335 and 1928, p. 363) described as unfossiliferous, hard, green, and purple siliceous shale and irregular intercalated massive beds of gray and purple compact limestone; a section which begins just above the Pass and continues 800 feet (est.) upward, where it is in contact with the Mahto.

The formation is of particular interest because of the presence, in a pre-Mahto limestone (called Hota by Walcott, but, by definition, Tah), in the base of Mumm Peak, above the Mural Glacier, of a most unusual assemblage of Lower Cambrian Olenellid trilobites—the "new Lower Cambrian subfauna" of locality 61k. First discovered in a drift block on the glacier, it was traced to a cliff and referred to the Mahto (Walcott, 1913a, pp. 311-316). Three days later it was called Hota (Walcott, 1913b, p. 339). Resser questioned Burling's use of Mahto (Burling, 1916c, pp. 158-159) in a personal communication which said that Walcott affirmed the correctness of the reference to Hota. But the question is not whether to use Hota or Mahto, because the fauna actually occurs in a pre-Mahto formation, which is the Tah by definition, regardless of the fact that it is abundantly fossiliferous above Mural Glacier, and unfossiliferous above Moose Pass. In the Mural-Glacier the "new Lower Cambrian subfauna" (61k) occurs 550 feet below the top of the Tah formation and contains: Cystid?, *Lingulella chapa, L. hitka, Mickwitzia muralensis, Obolella nuda, O.* cf. *chromatica* Billings, *Hyolithes* sp., *Callavia eucharis, C. perfecta, Wanneria occidens, Olenellus truemanni, Hymenocaris* sp.—all Walcott except *Obolella* cf. *cromatica.*

Since the Tah formation had been so confused — stratigraphy, fauna, occurrence, and lithology—Mural was proposed (Burling, 1923, pp. 774-746) for a very fossiliferous formation which was only Tah because both underlay the Mahto. Walcott (1928, p. 355) thinks Mural will be discarded when someone studies his section of the Lower Cambrian in Tah and Mahto Mountains. The finding, in the unfossiliferous pre-Mahto Tah, of the "new Lower Cambrian subfauna" credited to the post-Mahto Hota, will leave only the confusion and the specific differences between the two widely separated localities as arguments for the validity of Mural as a facies of the Tah.

TATEI CLIFFS AND TATEI FORMATION

Proposed as Tatay by Walcott (1913b, p. 334, and pl. 56) and accepted as Tatei by the Geographic Board, for cliffs southwest of Coleman Brook, which are southwest of the two talus-separated cliffs for which the name Chetang has been suggested.

Walcott (Idem, page 338) describes the Tatei as massive-bedded, gray, siliceous, and arenaceous limestones, 800 feet (est.) in thickness, and without fossils, occurring typically in Tatei Cliffs. Burling (1923, pp. 724 and 740) found 1,000 feet of Tatei beneath Titkana at the base of the Titkana Peak section, but upper and lower boundaries there may not be identical with those in the cliffs. This is, of course, the locality where the Mumm was studied, and the reason for such a duplication between Tatei Cliffs and basal Titkana Peak will probably be found in Walcott's suggestion (1928, p. 354) of faulting between Chetang Cliff and Titkana.

The Tatei formation also occurs at the base of the section in Mount Hitka, where the section was called Tatei overlain by Hitka (Idem). On page 250 of the same reference, Walcott suggests that "the Tatei is probably a relatively local deposit and may not be recognized outside of the Robson district."

The statement (Walcott, 1928, p. 353) that Chetang with *Albertella* in a lower cliff and Tatei in an upper cliff carries the section to the top of the Chetang cliffs, does not agree with figure 35 on page 354, and is incorrect.

TITKANA FORMATION AND TITKANA PEAK

Titkana Peak (9,320 feet) was first called Ptarmigan Peak by Coleman. Since this involved duplication with a mountain in the Canadian Pacific Railway section, Walcott proposed Titkana for the mountain and this name was validated by the Geographic Board.

The Titkana formation in Titkana Peak is complete from a capping of basal shallow-water Lynx to the bottom, where basal Titkana is in observable contact with the Tatei formation. It is described (Walcott, 1928, pp. 248 and 360) as 2,200 feet thick and as comprising massive-bedded bluish-gray limestone in thin layers interbedded at irregular intervals with hard, gray, buff-weathering dolomites in bands 50 to 100 feet thick.

Two fossil horizons were secured (Idem, p. 361), an upper (61v) one mile east of the summit in a cliff above the Robson Glacier with a Stephen fauna made up of: *Micromitra zenobia, Obolus mcconnelli, Obolus septalis, Acrotreta* cf. *depressa, Wimanella borealis, Hyolithes carinatus* Matthew, *Selkirkia major, Agnostus montis* Matthew, *Zacanthoides spinosus,* and *Dorypyge dawsoni*—all Walcott, but the *Hyolithes* and *Agnostus;* and a lower (61l and 61m) estimated to be 1,000 feet lower (than 61v) about 1.5 miles west-northwest of the summit of the peak on the slopes above Lake Adolphus with: *Acrotreta, Agnostus, Dorypyge,* and *Zacanthoides.*

In the sky-line section of Titkana Peak (Walcott, 1928, pl. 104) the 50 to 100 foot massive banding almost disappears, and fossil horizons were common enough to enable Burling (1923, pp. 738-739) to find both of Walcott's horizons. The upper (61v) with the Stephen fauna is 600 feet above the base of the formation, and the lower one (61l and 61m) occurs in its basal layers. This identification of the Stephen faunules is used under the heading Robson (Mount).

"In the future (Walcott, 1928, p. 248) the Titkana, as a formation, may be found to change its lithological character and volume from place to place, and it will then receive distinctive names."

TOKANA MOUNTAINS

Proposed (Walcott, 1913b, p. 329) for "the ridges (pl. 55, fig. 1) east and northeast of Moose Pass, which (legend of plate 55) are Upper Cambrian, and which (p. 329) repeat the Upper and possibly the Middle Cambrian beds of Mount Lynx, and Phillips and Titkana mountains." (See Moose Pass for thrust faulting between Tah Mountain to the southwest and the Tokana Mountains to the northeast.)

TONQUIN VALLEY, see Cavell quartzite.

TOOT-TOOT (MOUNT), see McEvoy (Mount).

WAKPA POINT, see Lake Kinney Station.

WAPTA POINT, see Lake Kinney Station.

WHITEHORN MOUNTAIN

Walcott (1927, p. 172) speaks of the mountain as made up of Proterozoic Beltian sandstones and shales.

YELLOW BAND, see Chetamon, Palisade, Roche Miette, and Snaring River.

YELLOWHEAD PASS AND YELLOWHEAD MOUNTAIN

McEvoy (1900, p. 78A) describes gray schistose conglomerate, greenish gray schists, and blackish argillites in the bottom of the valley. Behind intervening foothills the mountains northwest and southeast expose great thicknesses of fine-grained

gray quartzites above 150 feet or more of gray coarsely crystalline dolomite. In Yellowhead Mountain (Idem, p. 32D) no exposures were seen for 1,400 feet, where a 200-foot bed of "flat-lying rusty-weathering light gray crystalline dolomite is overlain by 1,400 feet of light gray crystalline dolomite, and overlain again by 1,400 feet of gray quartzites to the top of the mountain . . . These beds may belong to the horizon of the Castle Mountain group of McConnell's section or possibly to the upper part of the Bow River series. They are, however, always distinctly separable from the other rocks of the last-named series. Mount Fitzwilliam on the south side of the pass shows the same arrangement of rocks, the rusty band of dolomites toward the base being capped by the darker quartzites."

See Miette formation for rocks north and south of the Pass from Grant Brook on the west to Fitzhugh on the east, and in Mounts Fitzwilliam and Pelee.

See Mounts McEvoy and Hutam.

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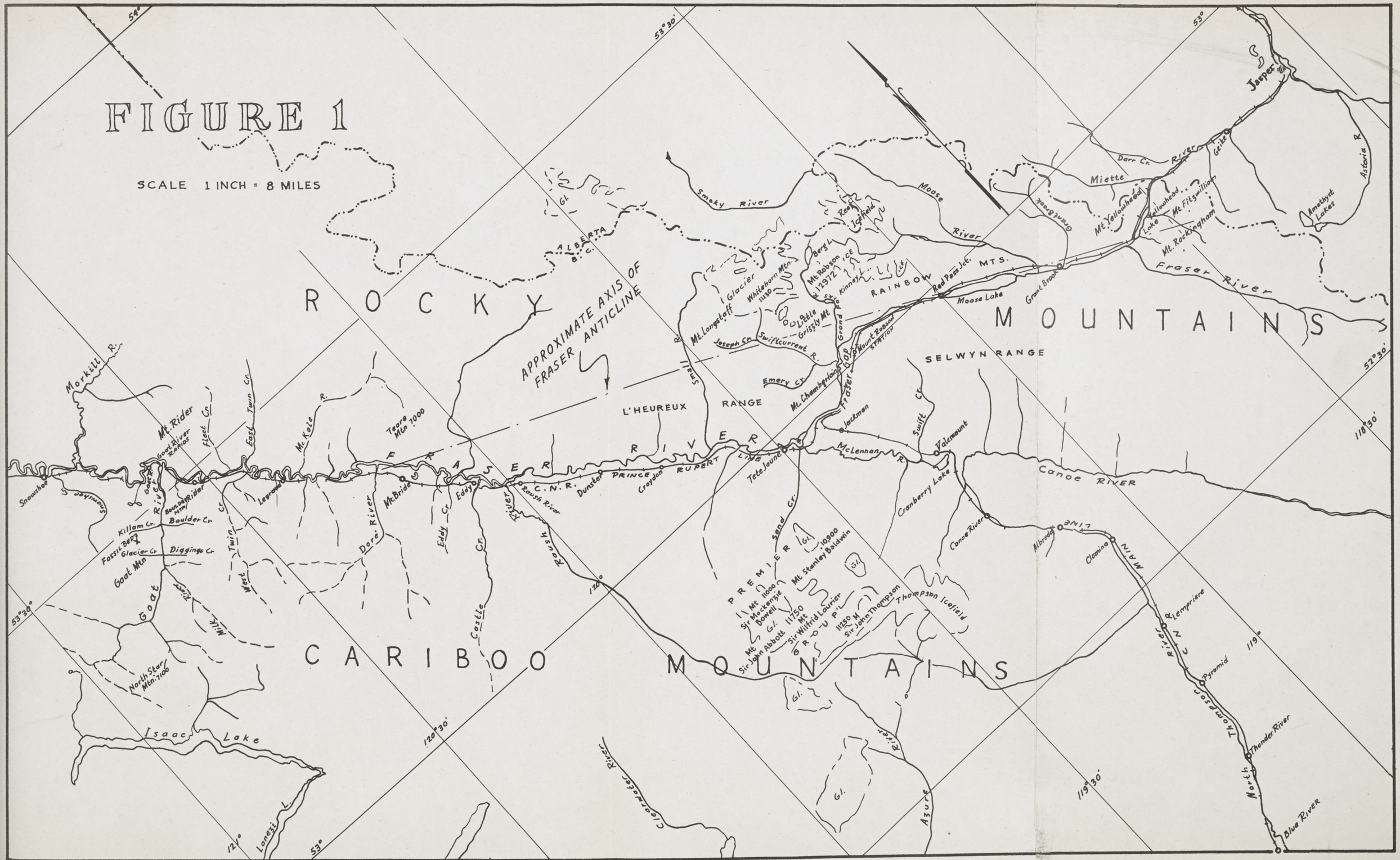
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FIGURE 1

SCALE 1 INCH = 8 MILES



SOME OBSERVATIONS ON THE GEOLOGY OF THE ROCKY MOUNTAIN TRENCH BETWEEN LATITUDES 53° AND 53°30′

MARSHALL K. SORENSEN*

The area covered in this paper is from Tête Jaune Cache, which is about Latitude 53° in the Rocky Mountain Trench, northwestward along the trench to Goat River at Latitude 53°30′, a distance of about 60 crowflight miles.

The area around Tête Jaune was visited by James McEvoy in 1898, and by G. S. Malloch in 1909. McEvoy came through the Fraser Gap at Tête Jaune from Edmonton and Jasper, but due to the lateness of the season was unable to extend his observations very far along the trench in either direction. Malloch's trip was a hurried one, southward from Fort (now Prince) George. He also was hampered by the lateness of the season. Both these men passed through the country before the railway was constructed, prior to World War I.

Charles D. Walcott visited the adjacent Mt. Robson area in 1912, and Lancaster Burling in 1915. Before reading this paper it is recommended that you read Lancaster Burling's contribution in this volume.

At Tête Jaune the Rocky Mountain Trench is bounded on the southwest by probable Proterozoic Pre-Beltian sediments, mostly altered clastics, and on the northeast flank by more or less altered sediments of the Proterozoic Beltian Miette formation.

Dealing with the northeast, or Rocky Mountain, side first, we have a broad anticlinal complex at the Fraser Gap at latitude 53°, where the Fraser River enters the trench. The Fraser has been following the strike of the broken crest of this anticline for 30 miles from its entry to it at Mt. Yellowhead (PLATE 1). The core of this anticline exposes argillites and derived schists (see PLATE II) and the flanks arkoses of various grit sizes from sandstone to conglomerate, also with some alteration to schist. The grit portion was called the Bow River conglomerate by McEvoy, and placed above the finer beds. McEvoy assigned this whole series to the Lower Cambrian, but Walcott believed the horizon to be Algonkian-Beltian, and renamed it the Miette formation, thinking it the equivalent of the Hector and Corral Creek formations farther south. For the purpose of this paper the name Miette will be used.

The northeast flank of the anticline commonly has steeper dips, with less contortion, than has the southwest flank, where the dip is in places of low angle, with considerable flexure. In some places this limb is broken into thrust fault blocks.

When the Fraser reaches the gap at Mt. Robson it turns left and cuts across strike for five miles (see PLATES 3, 4 and 5), breaking into the Trench. At road level, this route ascends a series from argillite through arkose. At the east end of the Grand Forks bridge, numerous slabs of argillite can be examined in the bench. The river is here cutting through the debris from a snow chute on Little Grizzly Mt., immediately to the west. From Swiftcurrent bridge to the Tête Jaune bridge, the arkose section is ascended gradually, the dip being interrupted by many contortions and deviations (see PLATES 6 and 7). About a half mile east of the Valemount turn-off is a

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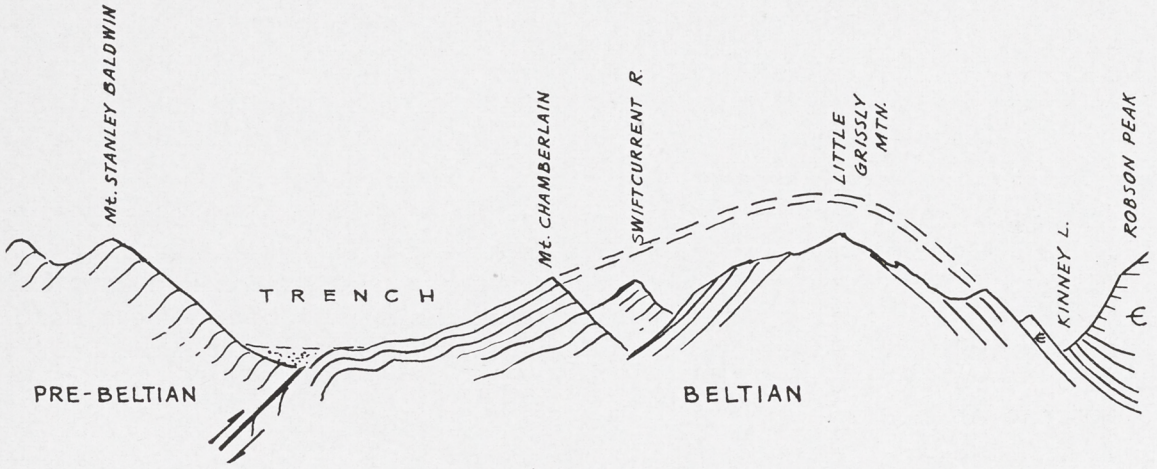


FIGURE 2

SCHEMATIC CROSS-SECTION AT LATITUDE 53° SHOWING FRASER ANTICLINE IN RELATION TO TRENCH AND MAIN RANGE. FRASER GAP AREA

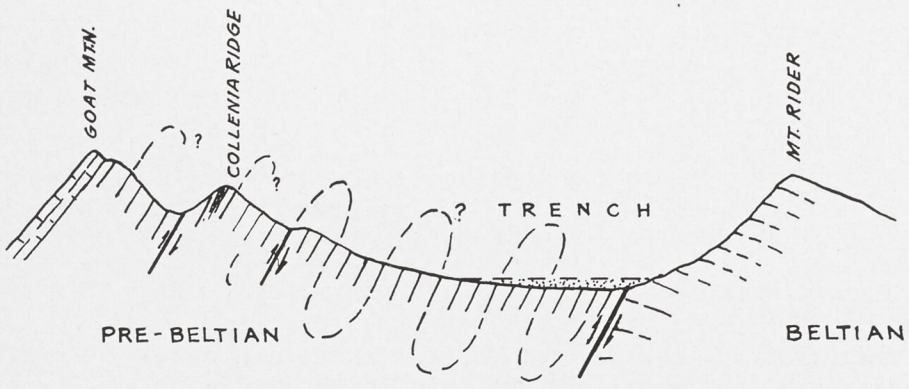


FIGURE 3

SCHEMATIC CROSS-SECTION AT LATITUDE 53°-30' SHOWING WHAT ARE PROBABLY ISOCLINALLY FOLDED BEDS THRUST UP ON THE NORTHEAST FLANK OF THE FRASER ANTICLINE.



PLATE 1.

Looking eastward from Fraser River bridge. Mounts Fitzwilliam and Clairvaux (small pyramid) on left, Mt. Rockingham on right. West dips on Rockingham and east dips on Clairvaux indicate the anticline along which the Fraser follows to the Mt. Robson area. The base of Fitzwilliam is Miette, but the bulk is probably Lower and Middle Cambrian. The Fraser enters from right, turns and flows along the strike of the anticline behind the photographer.

Photo: Marshall Sorensen.



PLATE 2.

Steeply dipping Miette argillite mineralized with pyrite crystals, on the Rainbow Mountains, the northeast flank of the Fraser anticline between Red Pass and Mt. Robson. McEvoy's report indicated Cambrian rocks above on mountain tops in this area.

Photo: Marshall Sorensen.



PLATE 3.

Looking southwest through the Fraser Gap, Mt. Robson area, toward the "Mica Mountains" of the Premier Group of the Cariboo Mountains across the trench. The Fraser breaks through the southwest flank of the broken anticline, and cuts across the strike of the Miette formation and into the trench. The Fraser remains in the trench until it turns southward at Prince George. Mountain shoulder on left is northern terminus of Selwyn Range; shoulder on right is Mt. Chamberlain. Premier Mountains are formed of gneiss and schists of Téte Jaune horizon of McBride Group.

Photo: Marshall Sorensen.

ridge (PLATE 8) which is a good example of confusion of dip and contortion, resulting, no doubt, from thrust pressure from the hanging wall of the trench fault (Premier Mountains—see PLATE 9 and Fig. 2).

One mile west of the Tête Jaune bridge, on the northeast rim of the trench, is a saddle, in what is known locally as the L'Heureux Range, from which the photograph for Plate 10 was taken. A conglomerate bed crops out, dipping southwest. This may match McEvoy's conglomerate on the mountain east of Cranberry Lake (1901, p. 37D) and may represent the bottom of the arkose horizon. Boulders of conglomerate may be seen around Swiftcurrent bridge. The Swiftcurrent river drains part of the Fraser anticline west of the Gap; it rises in Whitehorn Glacier, which lies between Mounts Whitehorn and Longstaff. As we ascend the Swiftcurrent a remarkable change takes place in river bottom material as Emery Creek is passed (the first big creek on the left). The boulders and gravel in the main branch appear to be nearly all of carbonates, while Emery Creek gravels are mostly of clastics. This indicates that the Whitehorn Glacier is moving over Cambrian rocks. Plate 10 shows Mt. Whitehorn to appear similar to Mt. Robson in bedding, and it furthermore has the same coloring. There is gold in the gravels of Emery Creek and none in the gravels of the main branch. In fact, gold can be panned from any gravels that have their origin in the Miette.

Proceeding northwestward along the trench, the last westerly dips observed can be examined at road level at Small River (PLATE 11). These have the appearance of the flaggy limestones mentioned by McEvoy (1901, p. 36D) near the mountain top



PLATE 4.

Partial view of the south side of the Fraser Gap (north end of Selwyn Range) showing general west dip and accompanying contortions and flexures. Miette rocks dominate but some of the massive beds on high peaks behind may be Cambrian. The top railway line is the main line of the C.N.R.; the bottom line is the Prince Rupert C.N.R. line. After passing through the Gap, the main line goes south, angling across the trench and running down the North Thompson River to Kamloops; the Trans Mountain Pipeline follows the same route. The Prince Rupert line goes northwest along the trench after penetrating the Gap.

Photo: Marshall Sorensen.



PLATE 5.

Looking northwestward from Fraser Gap area at Little Grizzly Mountain—Mt. Chamberlain on left—Mt. Robson on extreme right. Little Grizzly consists mainly of Miette argillites, forming the core of the Fraser anticline. The upper grit portion of the Miette forms the east (right hand) flank of it and plunges underneath Mt. Robson (Walcott, 1928, p. 351), which is mostly Cambrian. Mt. Chamberlain on the left, on the other side of Swiftcurrent River valley, has the grit portion of the Miette beds dipping into the trench.

Photo: Marshall Sorensen.



PLATE 6.

West limb of small anticline in the Miette arkose between Swiftcurrent bridge and the trench. It is one of the typical flexures along this section.
Photo: Marshall Sorensen.

east of Cranberry Lake. It appears (Fig. 1) that the axis of the Fraser anticline makes an angle with the trench, and these west dips represent the southwest flank of it, plunging under the hanging wall of the trench fault.

The first easterly dips easily examinable from road level occur a few miles south of McBride (PLATE 12), and similar dips continue for thirty miles to Mt. Rider (PLATE 13). Mt. Rider is on the terminus of the northeast flank of the anticline as it plunges under the trench fault. Malloch (1909, p. 128) reported carbonates rimming the trench down river (northwestward) from there; these are probably Cambrian rocks overlying the Miette formation.

For convenience in describing the rocks along the southwest side of the trench, the terms used in the Comstock Consolidated reports will be adopted here. There are no measured sections, and no attempt has been made to correlate the section with the Windermere series to the southeast, the Cariboo to the southwest, or the Wolverine Complex to the northwest, although they resemble all these series in some respects.

The Tête Jaune horizon, consisting of pegmatite-intruded gneisses and schists, highly micaceous and garnetiferous, is the lowest represented. The Snowshoe horizon above it consists of chloritic and talcose schists, overlain by the Goat River horizon quartzites and carbonates. These three horizons make up the McBride group. McEvoy (1901, p. 38D) placed the Tête Jaune formation in the Archean, as did Dawson, and called it Shuswap; McEvoy also said that some of the finer grained gneiss was certainly intrusive. The author agrees with Malloch (1909, p. 127) that the only intrusive is the pegmatite, intruding what was originally a sedimentary rock.



PLATE 7.

Typical schistose arkose in the Fraser Gap; the bedding dips away and to the right. Quartz grit constituent becomes prominent on weathering; note particularly coarse bank by hammer.

Photo: Marshall Sorensen.

The McBride group is placed tentatively in the pre-Belt Proterozoic, although it could be in part the altered equivalent of the Beltian, perhaps being more highly metamorphosed, because of intrusion and the Nevadan orgeny than the Beltian to the northeast of the trench.

At Tête Jaune, the Premier Mountains form the southwest flank of the trench, and lie in the hanging wall of the trench fault (see Fig. 2 and PLATE 14). They are characterized by dip to the southwest at rather steep angles. The valley of the Raush River (River-au-Shuswap) appears to follow a fault line, with Snowshoe schists thrust up on to the Tête Jaune horizon. The "Back Country" rocks in the Azure Lake-Clearwater River area to the south are schists, possibly comparable to the Snowshoe Horizon (B.C. Minister of Mines Report, 1923, p. A157).

Northwestward down the Fraser from Raush River, no Tête Jaune rocks are seen, the Snowshoe being dominant on the southwest side of the trench. Near the mouth of Goat River, opposite Mt. Rider, are the Goat River Rapids, one of the few places in which bedrock is exposed at water level near the centre of the trench. According to Malloch (1909, p. 127), talcose and chloritic schists and quartzites cause the rapids. The only dips mentioned by Malloch are to the southwest.



PLATE 8.

Ridge on road just east of Valemount turnoff. Dips are to east in the undergrowth at left, vertical and contorted in centre. Farther up the mountain, the beds adjust themselves to strong southwest dips. Ridge is a good example of the confusion of dips in the Fraser Gap.

Photo: Marshall Sorensen.

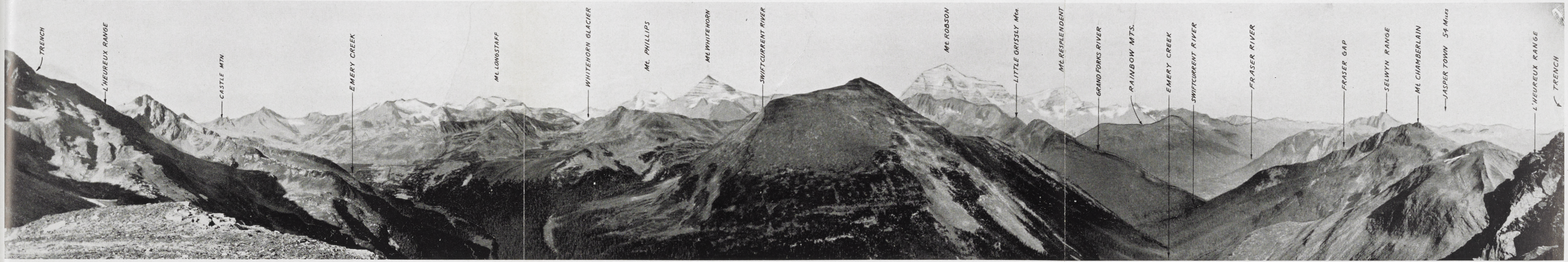


PLATE 10.

Latitude 53°, looking northeastward from L'Heureux Range. Trench immediately behind camera position. Beds of Miette conglomerate and schist can be seen on right dipping into the trench. Mountain in centre between Emery Creek and main branch of Swiftcurrent has beds dipping toward camera position. Photo: Marshall Sorensen.



PLATE 9.

Contortion in Miette rocks as the Fraser River leaves the Gap, at the south end of the Fraser bridge at Tête Jaune. Location was chosen for bridge because of the canyon feature. Rocks here are schistose sandstones and argillites, particularly chloritic.

Photo: Marshall Sorensen.



PLATE 11.

Flaggy limestone and schist dipping steeply southwest on west bank of Small River at road level. These beds represent the southwest flank of the Fraser anticline plunging under the trench fault.

Photo: Marshall Sorensen.



PLATE 12.
Yellow schists dipping northeastward just east of McBride at road level. This feature, rising from the Fraser bench (which is good farmland) can be followed several miles down river (northwest) from McBride. The rocks form part of the northeast flank of the Fraser anticline.
Photo: Marshall Sorensen.

The Goat River enters the trench from the southwest, cutting across the strike of the Cariboo Mountains for twenty miles (see PLATE 15). The old Indian trail up the river was used as a shortcut to Barkerville during the gold rush days (1860-1905). Because the Goat cuts across the strike of the country rocks at right angles it exposes a good section. Malloch's description of the Goat River Rapids placed the schists in the Snowshoe horizon. These chloritic and talcose schists would extend, in this case, from the mouth of the Goat River ten miles upstream, or over fifty thousand feet (see Fig. 3). There is no evidence of isoclinal folding, other than some flexuring southeast of Boulder Mountain, visible from the *Collenia* fossil bed locality (Fig. 1 and PLATE 18). However, it may be safer to assume that it is present; part of the section may also be repeated by faulting. Evidence of two fault features is seen seven miles upstream at Boulder and Killam Creeks, and nine miles upstream at Diggings and Glacier Creeks; these pairs of creeks enter the Goat from opposite sides, and mark the loci of thrust faults. At the Boulder-Killam fault zone, a medium temperature galena vein is seen on the west side, probably connected with the fault itself. The Goat River flows through a wet belt, which is heavily timbered. Cedar trees forty feet in circumference were noted. Devils clubs in the timber is a nuisance, and alders along the banks of the river, creeks, and "draws" make going difficult. There are numerous good outcrops along the river (see PLATE 16), and occasionally along the trail. The mountain sides above the river bottom carry a thin mantle of soil, and often when the bigger trees are blown down bed rock is exposed, making it possibly to gather data at reasonable intervals.

From the seven mile point, on the west side at Killam Creek, the schists seem to become more talcose proceeding up the Goat. An interesting feature can be seen in two of the smaller creeks farther up stream on the west side. They have steep flume-like channels cut along the strike of the talcose schists. The schists are contorted along



PLATE 13.
Looking northeastward across the trench toward Mt. Rider and Haggard Glacier; rocks of the Miette formation dip away from the camera. Photo: Marshall Sorensen.



PLATE 14.
Looking southwestward across the Trench at Latitude 53°. The Premier Group of the Cariboo Mountains consists of the Tête Jaune intruded gneiss and schist, dipping away from camera at steep angles. Camera position is on L'Heureux Range, the southwest flank of Fraser anticline, in the Miette formation which also dips to the southwest. Sand Creek enters the Fraser River in centre of picture; McLennan River on left. Although the McLennan is only a fraction the size of the Fraser, and occupies the trench to the southeast, there is no apparent change in the physiography of the trench. This may be evidence that the trench was not formed by stream erosion. The Fraser has just entered the trench from the left and is flowing to the right, northwestward, in the trench. This is as far as the salmon run in the Fraser.
Photo: Marshall Sorensen.



PLATE 15.
Looking up Goat River from bench on Boulder Creek, seven miles from the mouth of the Goat; view is across the strike of the Cariboo Mountains. Snow capped mountain on right is Goat Mountain. Barkerville is forty-five miles away, beyond the peak of North Star Mountain in the far distance. Photo: Marshall Sorensen.

strike and have numerous "swirls." Some of these have more or less round "pipes" of post-contortion quartz in them; the schist being soft, the quartz sticks out like tree stumps.

The Goat River carbonates are met about ten miles above the mouth, where the shoulder of Goat Mountain is passed. The abrupt change is quite obvious from river level, from the boulder and gravel colors. The carbonates are buff- and brown-weathering. Gold can be panned in the river up to the point where the carbonates are met. Brown garnets are quite common, most of them about pea size.

The only fossil found so far in the trench, within the area dealt with in this paper, is apparently a new *Collenia* (see PLATE 17). To reach the fossil bed it is necessary to climb the hogback on the south side of Killam Creek to the timberline. A twenty-foot thick bed of buff-weathering dolomitic limestone is made up almost entirely of the *Collenia,* which is immediately obvious in the rocks exposed above the timber (see PLATE 18. The limestone is underlain by quartzites of unknown thickness; above it is a well defined quartzite formation, one hundred and fifty feet plus in thickness. The author examined a little peak to the left (east) of that shown in Plate 18, and found this thick quartzite bed forming its top. On Plate 18, some less massive beds can be seen above the quartzite; these were not examined due to weather and fatigue. No doubt the *Collenia* bed and the quartzite bed above it could serve as markers in measuring sections, and correlating, in the future.

The view northeastward across the trench (PLATE 19) was taken from the same camera position as Plate 18, but in the opposite direction. To the left of Mt. Rider there is a large swampy tract, which extends to the mouth of the Morkill River (Little Smoky). The peak of Mt. Sir Alexander, 10,740 feet, can be seen in the distance.



PLATE 16.

Goat River Canyon, about six and one-half miles from the mouth; typical chloritic schists of the Snowshoe horizon dipping upstream (southwest). Photo: Marshall Sorensen.



PLATE 17.

Collenia, discovered by the author, and apparently a new species, is the only fossil discovered so far in the area covered by this paper. It may eventually help in determining the exact age of the Snowshoe and Goat River horizons. The adjacent Palaeozoic rocks across the trench, beyond the Miette rim, are not known to contain *Collenia.* Picture is taken on block broken off bed, which may be overturned. Photo: Marshall Sorensen.



PLATE 18.

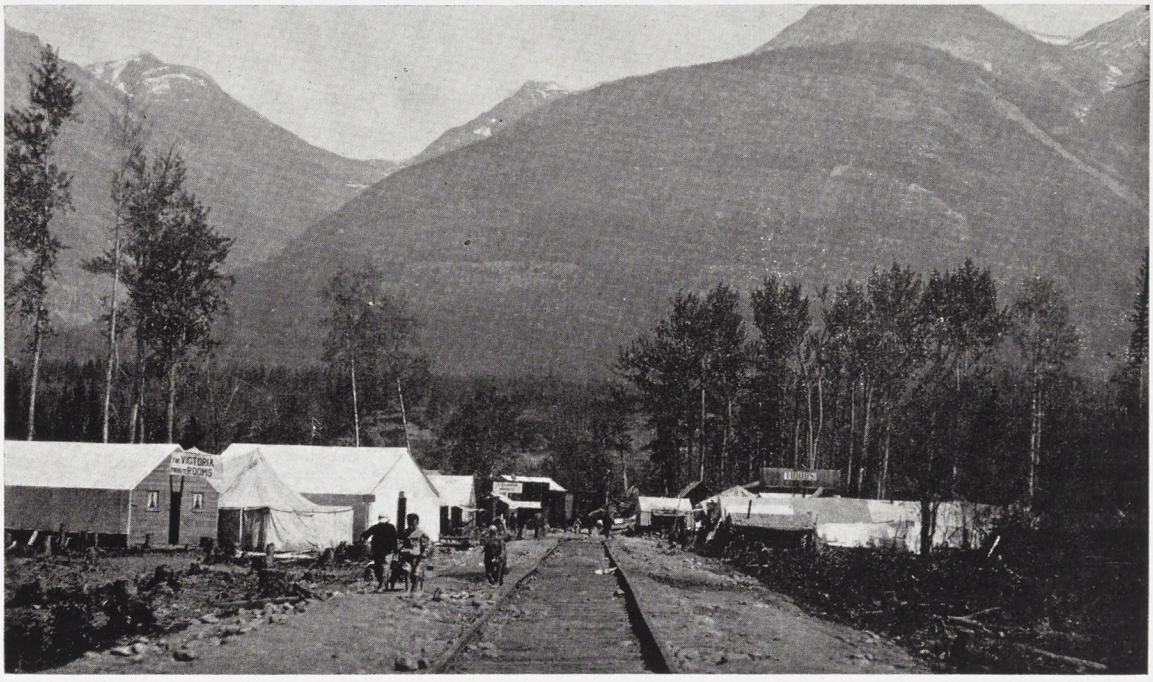
Cliff of dolomitic limestone and quartzite overlain by thinner beds. *Collenia* algae make up the lowest twenty foot thick bed of grey, buff-weathering dolomitic limestone, overlain by a massive bed of light limonite-stained quartzite, one hundred and fifty feet thick. They are the first beds exposed above the timberline on the west side of Goat River. These beds may represent the bottom of the Goat River formation, as beds so unaltered are unlikely to occur in the talcose schists of the Snowshoe horizon. Photo: Marshall Sorensen.



PLATE 19.

Looking northeastward across the trench at latitude 53° 30'N. Mt. Rider and Haggard Glacier at left. Trench is here about ten miles wide. Miette formation across the trench is dipping away from the camera, and Snowshoe rocks from camera position dipping towards it.

Photo: Marshall Sorensen.





TETE JAUNE CACHE, B.C., 1913

Téte Jaune is in Rocky Mountain Trench at Lat. 53°N. It was a wild and woolly railway construction town. Canadian Northern and Grand Trunk Pacific both used the facilities set up there by private individuals. It later burned down and Valemount, 15 miles away, took over.

Photos from the collection of Marshall Sorensen.

ECONOMIC GEOLOGY

There are no mines operating in the district. The Miette formation releases fine gold on weathering; it has numerous iron-stained quartz veins, nearly all carrying a show of gold. The Snowshoe horizon also releases gold on weathering, but the Tête Jaune and Goat River horizons do not. The bars along the Fraser have been placer mined by small operators over the years, but high water hampers the operations for much of the season. Placer mining has been carried on along some of the Fraser tributaries as well; the Swiftcurrent and Goat Rivers are two of the more prominent.

At Tête Jaune there has been some interest, spasmodically since the nineties, in the muscovite mica associated with the pegmatite intrusives (McEvoy, 1898, p. 39D; Malloch, 1909, p. 127). Sheets of good quality, slightly greenish muscovite, up to twenty inches across, have been mined. However, the economics of mining such deposits must be poor, and even the mica demand of World War II did not see the mines in operation. Mt. Stanley Baldwin is the main "Mica Mountain," but deposits are known on other mountains to the southeast.

Large parts of the district have not been thoroughly prospected, in part because of wet belt conditions. Rain, heavy timber, lush undergrowth, alders, and other obstacles make prospecting discouraging except for a few dry weeks in the fall.

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GEOLOGY OF PORTIONS OF SUNWAPTA AND SOUTHESK MAP-AREAS JASPER NATIONAL PARK, ALBERTA, CANADA †

RICHARD D. HUGHES‡

INTRODUCTION

This report deals with the results of a field-geological study and mapping program in the Sunwapta River area of the central Rocky Mountains carried out during the summer of 1951.

Three aims were proposed originally as bases for investigation. Structural conditions in the selected area were to be resolved by surface mapping. Stratigraphic information was to be obtained from measured sections. Lastly, it was hoped that fossil collections could be made which would be adequate for the correlation of the Sunwapta River stratigraphic section with Bow Valley and Mount Robson sections. These aims were successfully accomplished.

Pre-Cambrian, Cambrian, Ordovician, and Devonian strata are present in the Sunwapta River area. Distribution of these rock units is shown on the accompanying geologic map. The beds are folded into synclinal and anticlinal structures which, in turn, are broken and forced into thrust-fault structures. Conjectural cross-sections, given on the right hand side of the geologic map, illustrate probable structural conditions present in the area. Synclinal trends are occupied either by river and stream channels or by such prominent uplands as ridges and peaks. Anticlinal structures are characteristically breached along their axial trends. Fault zones in the area provide relatively weak channelways in which run-off waters are concentrated into brooks, creeks, and, in season, torrents. *Olenellus, Albertella, Glossopleura, Thompsonaspis,* and *Cedaria* faunal zones were discovered in Cambrian strata of the mapped area. An excellent correlation with Bow Valley section, and a fair correlation with the Mount Robson section is made possible owing to this abundant paleontologic evidence.

PREVIOUS WORK

The earliest geologic report on the central Canadian Rocky Mountains was made by James McEvoy[17] in 1900. In it he describes geology along the Miette River in the vicinity of Yellowhead Pass. Since 1912 D. B. Dowling, C. D. Walcott, L. D. Burling, E. M. Kindle, P. E. Raymond, J. A. Allan, R. L. Rutherford, P. S. Warren, and R. A. C. Brown have reported variously on Jasper National Park area. To the south, along the Bow Valley in Banff National Park, the pioneer geologists are C. D. Walcott, J. A. Allan, P. S. Warren, and F. Rasetti. A. P. Coleman[6] is ranked the out-

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† Based on a thesis submitted to the Graduate College, University of Oklahoma, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, April, 1953.

‡ Geologist, Bullock and Hughes Petroleum Geologists Ltd. The thesis on which this paper is based was prepared under the direction of Dr. E. L. Lucas, School of Geology, University of Oklahoma. Grateful acknowledgment for advice and constructive criticism is made to Drs. K. Arbenz, C. C. Branson, E. A. Frederickson, F. A. Melton, C. A. Merritt and other faculty members of the School of Geology. Mr. Vincent E. Kurtz assisted in the identification of Upper Cambrian trilobites. Kindnesses shown by Mr. and Mrs. Hayhurst, Mrs. Longman, District Warden George Camp, Park Warden Tom Ross, and Mr. Alex Roffey, of Jasper National Park, are deeply appreciated. Mr. George Little of Vancouver, Canada, draughted the areal geological map. Special thanks were due my father, the late Mr. Thomas Hester, of Vancouver, who accompanied me into the Sunwapta area where he maintained base camps, thus making possible the field program.

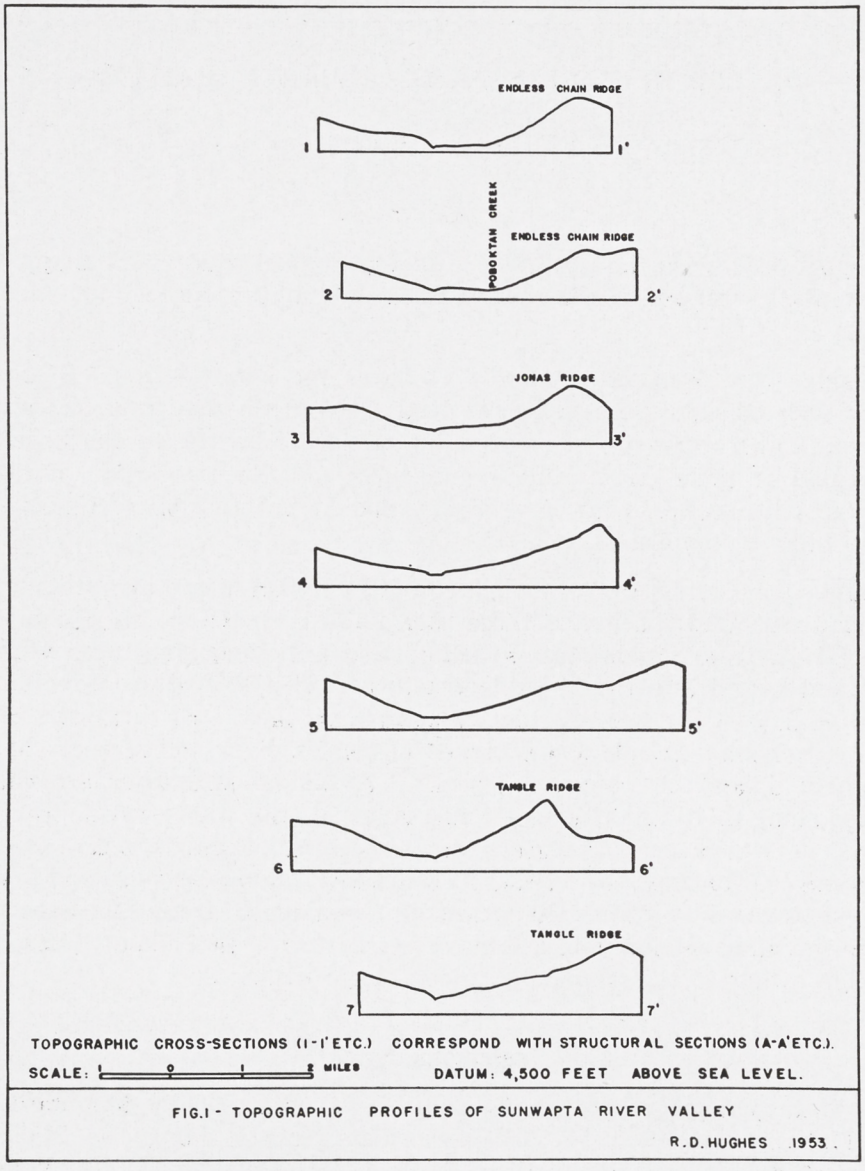


FIG. 1 - TOPOGRAPHIC PROFILES OF SUNWAPTA RIVER VALLEY

R. D. HUGHES 1953.

standing explorer of the central Rocky Mountains. His geologic writings on this region are restricted to reports on glacial phenomena. In 1892, Coleman was the first white man to traverse the pass which he named Poboktan. Howard Palmer and Alan Carpe visited the north part of Le Grand Brazeau range during a mountaineering expedition in the summer of 1923.[20] They made first ascents of Replica Peak and Mount Henry Macleod.

A paper by J. A. Allan[2] on Cambrian beds in the Sunwapta Pass area called attention to the need for geologic investigations in the region. Recently L. J. Severson[23] has described the post-Cambrian stratigraphy of sections in southermost Jasper National Park.

LOCATION AND ACCESSIBILITY

The geographic center of the mapped area lies close to the intersection of 52°20′ longtitude. The area comprises approximately one hundred square miles. It is located



PLATE 1.

Sunwapta Peak (10,875 feet). Photograph taken from the saddle at the southeast end of Tangle Ridge, showing the type area of the Sunwapta Peak formation on Sunwapta Peak. Tangle Ridge formation shales form the dark hill on the left side of the photograph.

east of Sunwapta River, south of Maligne Pass, west of Le Grand Brazeau†, and north of Wilcox‡, Jonas, and Poboktan Passes.

Banff-Jasper Highway provides access to the region from Jasper and Banff. This highway is open officially from the first of June to the fifteenth of October. It is gravelled throughout most of its length. Work began on the construction of a tarred surface during the summer of 1951. Current information on the road may be obtained from the Superintendent of Jasper National Park, Jasper, Alberta. Banff-Jasper Highway can be reached by Provincial Highway 16 from Edmonton, and also from Calgary via Banff on a surfaced highway which follows the old Banff Trail.

Jasper is on the main line of the Canadian National Railway. Daily bus service between it and Columbia Icefield Chalet, near Sunwapta Pass, is maintained during summer months. Taxi service is available and moderate in cost from Jasper to any point on the highway.

The main line of the Canadian Pacific Railway passes through Banff. Summer bus service is scheduled from Banff to Columbia Icefield Chalet, which is located five miles south of the mapped area.

During the tourist season, excellent accommodations are obtainable at Sunwapta Falls Bungalow Camp at Mile 35 (south of Jasper), and at Columbia Icefield Chalet.

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† A mountain range named after the Hudson's Bay Company factor in charge of Jasper House, 1861-62.

‡ The first traverse of this pass was made by W. D. Wilcox in 1896.



PLATE II.

Poboktan Creek fault line trace. The photograph, taken looking northward, shows the fault contact between Hector formation beds on the left and Tangle Ridge formation beds on the right.

Sunwapta River area may be reached from the Rocky Mountain foothills by pack train. Good forestry trails from Brazeau connect with the main trail into the mapped area. This follows Brazeau River from Tarpeian Rock to the cutoff for Brazeau Lake. Thence the trail leads through Poboktan Pass into the central portion of the Poboktan Creek-Sunwapta River area. An alternate route, from the foothills by trail, originates at Mountain Park and extends southward into the Rockies. It follows the north bank of Medicine-tent River to Southesk Pass and thence leads down Cairn River to its junction with Southesk River. Finally, four miles eastward along Southesk River, the trail from Brazeau to Poboktan Pass is reached. Pack trains may be used throughout the region. However, efficient travel by that means is restricted to the period of abundant horse feed between middle July and early October.

A campsite with firewood, shelter, and good drinking water is maintained by the Park Service on the east side of the highway at Jonas Creek. Field investigators should outfit with camping equipment in either Calgary or Edmonton since neither Banff nor Jasper merchants cater to tent campers.

STRATIGRAPHY

GENERAL STATEMENT

Strata of Pre-Cambrian, Cambrian, Ordovician, Devonian and Pleistocene age are present in the mapped area. A thickness of more than 11,000 feet of Pre-Cambrian, 4,700 feet of Cambrian, 770 feet of Ordovician, and 1,500 feet of Devonian accumulated in the region. A generalized stratigraphic section is inset on the accompanying geological map sheet. Regional correlation of the formations of the Sunwapta River Cam-

STANDARD SECTION	BOW RIVER VALLEY C.D.WALCOTT(1928) F. RASETTI (1951)	DOGTOOTH MOUNTAINS C.S. EVANS (1933)	SIFFLEUR RIVER-GLACIER LAKE C.D.WALCOTT(1928)	SUNWAPTA RIVER AREA R.D.HUGHES(1953)	MOUNT ROBSON L.D.BURLING(1923)	FAUNAL ZONES
UPPER CAMBRIAN	GOODSIR (LOWER)		LYELL	TANGLE RIDGE	LYNX	HOUBIA PROSAUKIA-PTYCHASPIS CREPICEPHALUS CEDARIA
	SABINE					
	SHERBROOKE					
	PAGET					
	BOSWORTH		SULLIVAN			
	ARCTOMYS 'PIKA'	CANYON CREEK	ARCTOMYS			
MIDDLE CAMBRIAN	ELDON		MURCHISON	SUNWAPTA PEAK	TITKANA	THOMPSONASPIS GLOSSOPLEURA
	STEPHEN					
	CATHEDRAL		CATHEDRAL		TATEI CHETANG	ALBERTELLA
	MOUNT WHYTE		MOUNT WHYTE	MOUNT WHYTE	ADOLPHUS	PLAGIURA-KOCHASPIS
	PEYTO LIMESTONE MEMBER		PEYTO LIMESTONE MEMBER	PEYTO LIMESTONE MEMBER		
LOWER CAMBRIAN		DONALD			MAHTO MURAL	BONNIA-OLENELLUS
PRE-CAMBRIAN AND (?) LOWER CAMBRIAN	ST. PIRAN	ST. PIRAN	ST. PIRAN BASE OBSCURED			
	FORT LAKE LOUISE MEMBER	FORT LAKE LOUISE MEMBER		JONAS CREEK	UN-NAMED SANDSTONE	
	MOUNTAIN	MOUNTAIN				
	HECTOR	HORSETHIEF CREEK		HECTOR		

FIG.2 - CAMBRIAN CORRELATION CHART FOR THE CANADIAN ROCKY MOUNTAINS R.D. HUGHES 1953

brian section is given in figure 2. The Pre-Cambrian section comprises a series of shales with intercalated pebble-conglomerate bands, overlain by quartzites. Cambrian strata include basal limestones, followed by argillaceous limestones with shale lenses, overlain by ochrous shales with interbedded limestones. The Ordovician system is made up of an older limestone formation (Formation A) and the younger quartzitic Mount Wilson formation. The latter separates the Ordovician system from capping Devonian shaly limestones. Volcanic activity, presumably submarine, occurred in late Pre-Cambrian time and resulted in the dispersal of basic igneous materials near local horizons in Jonas Creek formation. The sedimentary record from Upper Devonian to Pleistocene time has been removed from the area. Late Pleistocene glacial and fluvial deposits are present in the valleys.

PRE-CAMBRIAN

HECTOR FORMATION

The type area for Hector formation was designated by C. D. Walcott[26] (p. 428) to be Mount Hector which overlooks Bow River valley from its north side opposite Hector Lake. A shale unit at the base of the stratigraphic section in the Sunwapta River

area is the lithologic equivalent of the Hector formation and is assigned that name. This unit occurs in a lengthwise belt from Maligne Pass to Poboktan Pas, and ranges in width from one and one-half to three miles.

The gross lithology of the Hector formation was studied in the area. Exposed sections were not accessible, and accessible sections were too incomplete for detailed stratigraphic measurements. In general, Hector shales are friable and crumble on the surface into small angular chips which obscure bedrock.

The formation includes disturbed, locally faulted, pebble quartzite strata interbedded with thin shales at the north end of a small lake in Maligne Pass. These grade into an older sequence of poorly-cemented pebble quartzite and sandstone interbedded with green and ochrous shale beds on the north side of Replica Peak (PLATE XIV). In this locality differential erosion of the beds, which dip from fifty to seventy degrees westward, has resulted in a groove-and-ridge terrain. A specimen from Replica Peak contained white quartzite pebbles ranging up to thirty millimeters in diameter in a matrix of rusty-weathering sandstone.

The Hector formation along Poligne Creek comprises buff, gray, and green-gray slaty shales interbedded with pebble quartzites and conglomerates. The latter beds range up to twenty feet in thickness. The shales are foliated and fragmented; and the quartzites and conglomerate beds are sheared along smooth planes as a result of structural deformation.

The Hector formation consists mainly of green, friable, slaty shale, intercalated ochrous shale, and yellow, limonitic clay beds on Poboktan Creek one-half mile above its junction with Poligne Creek. Green, friable, sheared shales were found along Poboktan Creek south of Waterfall Cabin. The formation comprises interbedded poorly-cemented conglomerates, sandstones, and green shales in the low hills west of the cabin. At this locality a fault zone occurs and the shales contiguous to it are metamorphosed slightly. These exhibit abnormal hardness, platiness, and a minor content of secondary mica.

Grits, conglomerates, and shales of Hector formation are aligned along the crest of Jonas Shoulder. In the hills west of Poboktan Pass Hector formation shales are green, friable, slaty, and arenaceous (PLATE XXII). Fractures in these are filled with calcite veins.

Cross-section measurements show 6,000 feet of Hector formation between its upper contact with Jonas Creek formation and its lower fault contact with footwall post-Lower Cambrian beds. The stratigraphic thickness of the Hector formation in the mapped area is not known, owing to the fact that its base is not exposed; and due to duplication and omission of beds by faulting, crumpling, and shearing. Diagnostic fossils are lacking in the Hector formation.

PRE-CAMBRIAN AND (?) LOWER CAMBRIAN

JONAS CREEK FORMATION

The new formational name Jonas Creek is assigned to the predominantly quartzite rock unit between the top of the Hector formation and the base of the Mount Whyte formation. The escarpment on the east side of Sunwapta Peak massif opposite the point where Jonas Creek first flows above its mouth on Hector shale is designated as its type locality (PLATE XV).



PLATE III.

Replica Peak (9,167 feet), Coronet Mountain (10,340 feet), and Mt. Henry MacLeod (10,789 feet). Photograph taken from Jonas Ridge overlooking Poboktan Creek valley and Hector shale hills.



PLATE IV.

Maligne Pass. The photograph was taken looking northward toward headwaters of Poligne Creek. The escarpment face of Endless Chain Ridge is seen on the extreme left. Hector formation underlies the center and right parts of the scene.

The lower section of Jonas Creek formation is considered to be Pre-Cambrian in age. Beds of Lower Cambrian age may be included in its upper section. The formation is present along two trends in the area. One originates in Endless Chain Ridge and strikes south along Jonas Creek to Jonas Pass. The other occurs in Le Grand Brazeau. Sections of the formation were not measured owing to the fact that these are well exposed only on inaccessible cliffs. Cross-section measurements yield an approximate thickness of 5,000 feet for the formation. J. A. Allan[2] (p. 116) measured a thickness of 5,000 feet of quartzite and slate beds occupying the same stratigraphic position on Mount Edith Cavell near Jasper.

The quartzites of Jonas Creek formation on Endless Chain Ridge are mostly cream colored, and have green and red local stains. A few thin blue-green and ochrous shale lenses are found at this locality, and bands of conglomerate occur along the ridge crest. The basal bed of the formation was examined at the base of the escarpment on the east side of the ridge. It consists of rough-weathering, white quartzite locally ochrous and limonitic stained. Constituent grains are sub-angular, range from 0.2 to 0.8 millimeters in length, and contain secondary crystal outlines.

On Jonas Ridge red-and-pink-weathering, honey-colored quartzites, local pebble bandings, and interbedded shale lenses, constitute the principal rock types of Jones Creek formation. Cross-bedding in the quartzite strata, apparently derived by currents flowing from east to west, occurs at several places. Hand specimens of pink and yellow variegated quartzites, composed of grains ranging from 0.3 to 0.6 millimeters in diameter, were collected from the rock slide at Mile 47.5. Quartzite beds similar to those on Endless Chain and Jones Ridges are found in the canyon of Poboktan Creek one mile above the highway bridge. These also show cross-bedding.

Specimens of metamorphosed sedimentary rocks were collected from Jonas Creek formation on Jonas Ridge. Thin-sections of these contain metacrysts of a secondary greenish mineral (forsterite?), associated with detrital quartz and feldspar grains. Talcose and chloritic schists are found at this horizon locally. The origin of these rocks is believed to be the result of hydrothermal alteration of basic igneous material dispersed in normal shelf sands of Jonas Creek formation.

In the Brisco-Dogtooth map-area C. S. Evans[11] (p. 122A) found:

> An amygdaloidal basic flow, 20 feet thick, occurs between Donald strata and St. Piran formation on a mountain at the head of Oldman Creek, where it is exposed for 1,000 feet along the strike. Ten miles to the south-east a 60-foot bed, having lenticles 10 to 15 inches in length, of a fine-grained, greenish rock speckled with magnetite, in a sparse matrix of clastic material, occurs at the same horizon. Thin sections of the lenticles show lath-shaped outlines of plagioclase now largely replaced by calcite, and much euhedral magnetite. This rock may represent a pillow lava.

The quartzite beds exposed in Le Grand Brazeau were separated at the time of their origin from those cropping out in Endless Chain and Jonas Ridges by a probable distance of more than ten miles. Overthrusting and erosion has brought them within three miles of one another on the surface. Quartzites of the western trend are argillaceous and ferruginous. Those of Le Grand Brazeau, on the contrary, are characteristically strikingly clean, white and light-cream in color, and tan weathering. Generalizations are misleading, and it is emphasized that argillaceous, almost shaly quartzites also are



PLATE V.

Jonas Pass. The photograph, taken looking southward, shows an isolated quartzite mountain on the east side of the pass.



PLATE VI.

Tangle Ridge (9,845 feet). A photographic view from the northwest. The relief between the photographic station and Tangle Ridge summit is 4,645 feet.

found in the latter locality. The upper part of Jonas Creek formation contains *Scolithus* (?) tube fillings in its upper part in Le Grand Brazeau. This horizon was not located in the strata of Endless Chain and Jonas Ridges.

A prominent wedge shaped mountain on the northeast side of Jonas Pass is composed of Jonas Creek formation quartzites (PLATE XXII).

The Pre-Cambrian—Cambrian boundary problem within the mapped area remains open since tentative solutions are based on purely negative evidence: an absence of olenellid trilobites. Conformable relationships are believed to exist between Hector and Jonas Creek formation; and between Jonas Creek and Mount Whyte formations. Detailed regional tracing of these contacts in the future may reveal disconformities.

The oldest fauna in the stratigraphic section of the mapped area is an *Olenellus-Paedeumias* assemblage in basal Mount Whyte formation. It occurs close to passage beds which separate it from Jonas Creek quartzites. If this assemblage represents the first occurrence of olenellids, and not a recurrent fauna, then all strata older than Mount Whyte are of Pre-Cambrian age[28] (p. 157).

Two principal hypotheses have been advanced regarding the history of the Cordilleran geosyncline during late Pre-Cambrian and early Cambrian times. G. M. Dawson proposed "existence of an Archaean axis or geanticline in the present position of the Selkirks, or somewhat west of the Selkirks, which supplied the sediments to the Rocky Mountain (Laramide) geosyncline to the east."[19] (p. 20).

A possible alternative is presented for consideration by V. J. Okulitch [19] (p. 19) who writes:

> Although the Hamill and Fort Mountain-Lake Louise-St. Piran series represent the same rock-unit, there is no certainty that they were laid down contemporaneously. The writer is convinced that deposition of this thick sheet of dominantly sandy material began in the western Selkirks in late Precambrian time, crossed the Precambrian-Paleozoic time boundary in the eastern Selkirks, and was continued in the Purcell and the Rocky Mountains in Lower Cambrian time.
>
> A parallel situation applies to the overlying calcareo-argillaceous group, involving the Lardeau series, the Laurie formation, and the Canyon Creek formation. In their type areas, the Lardeau and the Laurie are unfossiliferous and presumably lie below the *Olenellus* zone. Eastward from the Selkirk Mountains a clastic series correlated with the Hamill quartzites is overlain by the Donald formation with Lower Cambrian fossils. If the Donald formation is equivalent to the Badshot formation, and the Canyon Creek formation to the Laurie, the rock-units again transgress time and become younger from west to east.

Figure 3 shows the insertion of Sunwapta River area Cambrian section on a chart illustrating the probable correlation of formations in Selkirk and Dogtooth Mountains by Okulitch[19] (p. 18). C. S. Evans[11] (p. 120A) discovered a single indentifiable Lower Cambrian fossil—a species of *Callavia*— in the upper twenty feet of the St. Piran formation in the Dogtooth Mountains. This trilobite was found associated with vertical worm burrows. C. Deiss has emphasized that, in his re-study of the Cambrian of the Canadian Rocky Mountains, "fossils were not found in strata older than the Mount Whyte"[8].

F. Rasetti[22] (p. 82) records collecting the youngest Early Cambrian faunule—*Bonnia fieldensis*—of the Bow River valley region from a limestone unit overlying the sandstones of the St. Piran formation. He assigns a Lower Cambrian age to the sandstones despite their unfossiliferous nature.

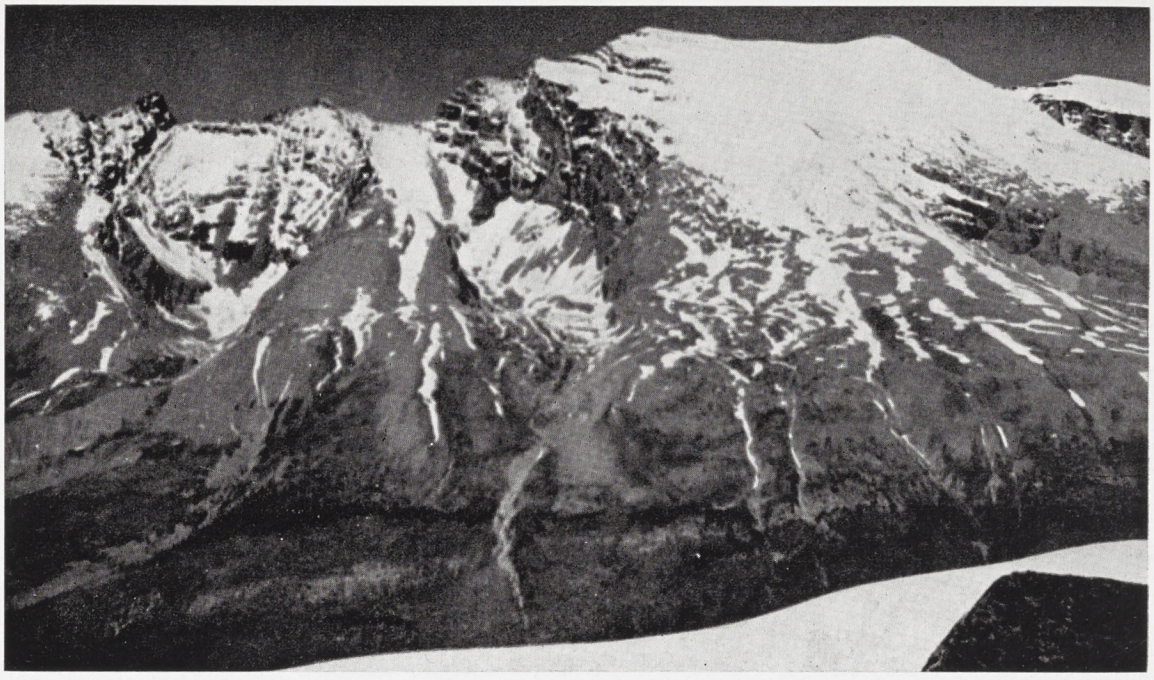


PLATE VII.

Poboktan Mountain (10,902 feet). Photograph taken in June, 1951. Light band near the base of the mountain is the surface trace of Poboktan Creek fault.



PLATE VIII.

Sunwapta Peak formation ridge on southeast side of Trinity Lakes.

LOWER AND MIDDLE CAMBRIAN

MOUNT WHYTE FORMATION

The Mount Whyte is the most consistent formation in the region. It was originally defined by C. D. Walcott[25] (p. 4) from type localities on Mount Whyte and on the eastern slope of Popes Peak. Descriptions of sections of the formation were published first in 1928[27]. C. Deiss later transferred the type section to Ptarmigan Peak[8] (p. 998). F. Rasetti has re-established the Mount Whyte type section in the area originally designated by Walcott[22] (p. 58). The three lithologic members, as described in the type section, are developed characteristically in the Sunwapta River area.

Mount Whyte formation comprises a lower limestone and dolomite member, a middle green-metargillite member, and an upper oolitic limestone member. The base of the Mount Whyte formation for purposes of field mapping was chosen at a gradational contact where Jonas Creek quartzites pass upward into predominantly calcareous beds. Lenses of quartzite and sandy limestone occurring above the contact are placed in the Mount Whyte. The upper boundary of the Mount Whyte was chosen arbitrarily at the contact of uppermost shale beds of the upper member with massive, dark-gray limestone of Sunwapta Peak formation (PLATE XVII).

F. Rasetti[22] (p. 55) has named the lower member of Mount Whyte formation Peyto limestone. Its best exposure in the mapped area occurs northeast of Trinity Lakes. It measures 140 feet in thickness at this locality, and conformably overlies slabby quartzite beds (PLATE XVI). The member is composed of silicified limestone and dolomite beds. The limestone is light-grey weathering, medium-gray, dense, and finely crystalline. The dolomite is mostly rich-buff weathering, light gray, dense, cryptocrystalline, and contains sparsely scattered quartz grains. Buff-weathering, gray, dense sandstone and quartzite, formed of rounded quartz grains ranging from 0.2 to one millimeter in diameter, occur in local lenses. The basal beds of the lower member crop out on the south bank of Jonas Creek at the highway bridge, and contain an olenellid fauna.

Locality F.20

Paedeumias sp.
Olenellus sp.
Litocodia sp.

Jonas Creek formation quartzites form the north bank. Concentrations of bun-like algal (?) concretions are present in lenses and mounds a short distance above the Mount Whyte-Jonas Creek contact. F. Rasetti[22] (p. 56) describes a layer of similar forms occurring at this stratigraphic position in the Bow Valley section, considers the forms probably inorganic, and recommends the layer as an excellent horizon marker. The lower member contains an olenellid fauna in the central Mount Whyte outcrop area of Le Grand Brazeau. Trilobites were collected from a thin limestone bed attacked to quartzite slabs.

Locality F. 26

Olenellus cf. *O. canadensis* Walcott

The lower member is exposed also on bedrock "islands" in Sunwapta River channel opposite Tangle Ridge, and contains mud cracks and other signs of contemporaneous sub-aerial exposure.



PLATE IX.

Jonas Ridge, un-named ridge above Jonas Creek camp ground, and Sunwapta Peak.



PLATE X.

Mt. Athabasca (11,452 feet) and Wilcox Peak (9,463 feet). Photograph taken looking southward from a station on the southern continuation of Tangle Ridge.



PLATE XI.

Diadem Peak (11,060 feet). This photograph shows alluvial fans and hanging valleys. It is noted that the altitudes of the mouths of the valleys are discordant.

The middle member comprises green, splintery, dense, locally talcose shale and metargillite interbedded with arenaceous phases. These rocks weather ochrous, green and buff. Local intraformational flat-pebble conglomerates are present near the top. The most accessible section of the middle member occurs on the west side of Tangle Ridge above the highway. Other exposures are found northeast of Trinity Lakes, in cols and on the escarpment face of Sunwapta Peak massif, and within the breached anticlinal structure of Le Grand Brazeau. Measurements of this member give thickness figures which provoke a problem. While a maximum thickness of several hundred feet is estimated for the member on Tangle Ridge, only ten feet is present in the Trinity Lakes area. Other measured sections have thicknesses between these extremes. Either a major erosional unconformity at the top of the member, or thickening and thinning by faulting could cause a thickness change of this magnitude. An unconformity is believed absent at this horizon according to regional information. The inconsistencies in thickness are considered to result from structural deformation since the member has flowed and is sheared at numerous localities in the area.

A species of *Paterina* was the only fossil found in the middle member in the mapped area.

A section of the upper member of Mount Whyte formation was measured on the west side of Tangle Ridge above the highway. The member is completely exposed at the foot of a high cliff formed by Sunwapta Peak formation, and is easily accessible. The section is on the west flank of Tangle Ridge synclinal structure. It was measured and thickness corrections were made for the beds which dip into the mountain at low angles. The description of the section follows:

LITHOLOGIC DESCRIPTIONS	THICKNESS	HEIGHT ABOVE BASE
	Feet	Feet
Shale, dark gray, fine bedded, friable with nodular limestone bands ranging up to eight inches in thickness	4.0	72.1
Limestone, gray, fine grained, dense	6.0	66.1
Shale, dark gray, splintery, slaty	1.0	65.1
Limestone, light gray, mammillary weathering	11.0	54.1
Limestone, dark gray, oolitic to dense, coquina in part, with very fine fingerprint-like markings	1.3	52.8
Shale, dark gray, splintery, hard, friable	8.0	44.8
Limestone, dark gray-blue, rusty to buff weathering, oolitic, with trilobite fragments	7.0	37.8
Shale, dark gray and putty colored, interbedded with claystone	0.5	37.3
Limestone, dark gray-blue, rusty to buff weathering	1.0	36.3
Claystone, interbedded with shale	1.5	34.8
Limestone, dark gray-blue, rusty to buff weathering, oolitic, locally pisolitic	0.8	34.0
Shale, medium gray, slight greenish cast, friable	4.0	30.0
Interbedded shale and limestone, buff and gray ribboned, nodular weathering, one-quarter to one inch beds	30.0	0.0

The upper member, because of its characteristic oolite content, is easily recognized and is a useful bed on which to map struc ture. To give an example: it was instantly identified on the summit of the next mountain (un-named) north of Diadem Peak and above Sunwapta River (PLATE XVIII). Hand specimens and thin sections of oolites were examined under binocular and petrographic microscopes. These oolites range up to 1.5 millimeters in diameter, and are surrounded with secondary calcite crystals measuring up to five millimeters in length. Concentric layering is lacking as a result of secondary replacement, and remaining original features are replaced by fine and medium-grained calcite crystals.

Oolites are common in certain Middle Cambrian formations of the Cordilleran region. They are found in abundance in the Mount Whyte formation in its type area,

and in the Mount Whyte equivalent in the Rocky Mountain ranges,[5] (p. 618) as well as in the Mount Whyte formation of Sunwapta River area. Oolites are found in the Middle Cambrian Damnation limestone† in northwestern Montana. Oolites are also widespread in Upper Cambrian Dresbachian age beds in the Cordilleran region[14] (p. 54).

F. Rasetti[22] (pp. 54-55) transfers the lower member (Peyto limestone) of Mount Whyte formation to the St. Piran formation in an attempted revision of the Lower Cambrian. His reasons for this step are given as follows:

> The St. Piran chiefly consists of thick-bedded sandstone and quartzite with some inter-stratified siliceous shale . . . Near the top, calcareous material appears; . . . Often calcareous sandstone or sandy limestone first appears as isolated lenses in the upper portion of the sandstone. Olenellid fragments and *Bonnia* are almost invariably present in the calcareous layers . . . It is clear both from stratigraphic and faunal evidence that there is no break between the underlying siliceous sandstone and these more or less calcareous (more rarely dolomitic) beds, hence a formational contact placed between them (as it was hitherto done) would be to a large extent arbitrary. On the other hand, both stratigraphic and paleontologic arguments favor placing a formational boundary at the top of the *Olenellus beds* . . . A sharp change in lithology also generally occurs, the crystalline sandy limestone usually in thick beds being overlain by siliceous shale with interstratified thin limestone or sandstone layers. In most of the sections (see descriptions) the St. Piran-Mount Whyte contact as here defined can be located within a few inches without ambiguity. Furthermore, the erratically varying thickness of the Mount Whyte (see discussion of formation) makes it appear likely that this unit was deposited on a somewhat irregular surface. This fact, coupled with the sudden faunal and lithologic changes, strongly suggests an unconformity at the top of the *Olenellus*-bearing beds. Hence all arguments favor placing the St. Piran-Mount Whyte boundary at the top and not at the base of the *Olenellus*-bearing limestone or calcareous sandstone, contrary to current usage. An analogous suggestion was first made by Burling (1914-1916).
>
> The St. Piran-Mount Whyte boundary as here defined is at the same time the Lower-Middle Cambrian boundary according to the faunal definition later discussed in this paper. The writer does not believe that series boundaries must necessarily coincide with unconformities and formational boundaries, but in the present instance, in the area investigated, this happens to be the case.

It is the opinion of V. J. Okulitch that the Pre-Cambrian Badshot limestone of the Selkirks may be the rock unit equivalent of the Donald formation of the Dogtooth Mountains[19] (pp. 18-19). The Donald formation, in turn, occupies the same stratigraphic position as the Peyto member of the Mount Whyte formation. Hence Rasetti's main argument for a revision—a possible unconformity at the top of the *Olenellus*-bearing beds—is perhaps invalid.

The geological nomenclature used in the present report conforms, as closely as possible, with rules adopted for official use by the Geological Survey of Canada. A sedimentary formation is described in these rules as "a lithologically distinctive product of essentially continuous sedimentation selected from a local succession of strata as a convenient unit for purposes of mapping, description, and reference[18]. Rasetti's stratigraphic arguments for transferring the Peyto limestone to the St. Piran formation are well taken. However, a formation is essentially a mappable rock unit, and neither

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† The Damnation limestone is equivalent to the part of the Sunwapta Peak formation that carried the *Glossopleura* fauna.



PLATE XII.

Crest of Jonas Ridge. Endless Chain Ridge appears in the center background.



PLATE XIII.

Upper Jonas Creek valley. Talus cones conceal the base of Jonas Ridge escarpment on the right. Jonas Shoulder is seen on the skyline at the extreme left.

the St. Piran formation nor the Mount Whyte formations, as revised by Rasetti, are mappable. The geologic boundary between the Peyto limestone and overlying Mount Whyte green shales lack topographic expression, but, on the other hand, the St. Piran sandstone-Peyto limestone contact is usually expressed as a sharp break or change in local topography. To give one example: St. Piran quartzites form the north bank and Peyto limestones the south bank of Jonas Creek at the highway bridge, and it is a simple task to trace this formational contact southeastward to the ridge above Jones Camp campsite. The contact between Peyto limestone and Mount Whyte middle shale member is obscured by surficial deposits in this area, and consequently not traceable. Similar conditions obtain for the Peyto limestone-Mount Whyte shale contact throughout the mapped area except on escarpment faces.

The transition from predominant sandstones of the St. Piran to the characteristic thick limestone sequence of the Sunwapta Peak is accomplished through an irregular alternation of sandstone, shale, and limestone beds. Abrupt changes are present throughout the section not alone at the top of the *Olenellus*-bearing beds as described by Rasetti. St. Piran formation is the main sandstone unit of the sequence, but sand lenses are distributed in the Peyto limestone, and arenaceous phases in the middle shale member of Mount Whyte formation. Blue-green shale lenses are found in middle and upper St. Piran, gray shale lenses in Peyto limestone, green shale beds in the middle member of the Mount Whyte, and gray shales in its upper member. Limestone beds occur in uppermost St. Piran formation; and in lower (Peyto limestone), middle and upper members of Mount Whyte formation.

F. Rasetti suggests that the re-defined St. Piran-Mount Whyte contact can be located within a few inches. Nevertheless, he notes on another page[22] (p. 24) of the same report, in a description of a section of Mount Whyte from near its type locality on Popes Peak, that for a 47 foot sequence of "alternating thin layers of siliceous, green-gray shale and green sandstone, with some thin, lenticular limestone beds. No fossils were found in this interval, hence it is uncertain whether it should be placed in the Mount Whyte formation or in the underlying St. Piran sandstone" (Peyto limestone member). It is not good practice to define a formation on its paleontologic content.

F. Rasetti suggests that the erratically varying thickness of the shale member of the Mount Whyte may be the result of deposition on an irregular surface. The writer believes that much of this variation is a result of squeezing and bulging by structural deformation. In the Sunwapta River area signs of contemporaneous subaerial erosion occur within, not at the top of, the Peyto member. There is no evidence, other than paleontological, for placing an unconformity at the top of the *Olenellus*-bearing strata.

The St. Piran-Mount Whyte formational boundary in Sunwapta River area is retained at the contact between St. Piran sandstone and overlying Mount Whyte limestone beds.

MIDDLE CAMBRIAN

SUNWAPTA PEAK FORMATION

It is proposed to name a sequence of limestone, dolomite, and minor shale strata between the Mount Whyte formation and overlying Upper Cambrian shales the Sunwapta Peak formation. Sunwapta Peak is designated as the type locality because at this place the sequence is developed typically and contains abundant fossil zones (PLATES I, XV).

The formation is widely distributed in the mapped area. One broad belt of it between Jonas Creek and Sunwapta River forms ridges which culminate in Sunwapta

Peak. Sculpture of a second belt east of Poboktan and Poligne Creeks gives rise to the mountains of Le Grand Brazeau.

Complete, accessible, measurable sections of the formation are lacking in the area. Cross-section measurements give a maximum of 2,500 feet and a minimum of 2,000 feet for its thickness. Sunwapta Peak formation is of such variable lithology that single measured stratigraphic sections have no areal significance. A partial section was measured on the northwest face of Tangle Ridge, and its description follows:

LITHOLOGIC DESCRIPTIONS	THICKNESS	HEIGHT ABOVE BASE
Top of section obscured		
Limestone, dark blue-gray, massive, rounded weathering, buff weathering.	15.0	647.0
Limestone, dark blue-gray, dirty-gray weathering, irregularly platy, chunky to nodular platy at base, more massive upwards.	105.0	542.0
Limestone, dark blue-gray, weathers pitted, shot with calcite nodules, massive to irregularly platy, local ripple marks, contains intra-formational conglomerate beds ranging up to three inches in thickness, becomes harder and denser upwards.	80.0	462.0
Limestone, dark bue-gray, buff weathering, nodular bedded and weathering.	15.0	447.0
Limestone, dark blue-gray, ribbed and furrowed to flat-surfaced, massive, becomes more platy toward the top.	95.0	352.0
Limestone, dark blue-gray, dense, fine crystalline, nodular bedding, weathers rusty and gray into sharp blocky fragments, becomes thin-bedded to platy upwards. Sparse worm trails.	130.0	222.0
Limestone, dark blue-gray, platy nodular; weathers rusty, gray and light buff; weathers ribbed and furrowed. Bedding ranges from one-half to one and one-half inches thick. Trace of trilobite fragments.	60.0	162.0
Obscured. Probably shaly limestone.	15.0	147.0
Limestone, very dark blue-gray, weathers into sharp square blocky fragments, becomes nodular weathering upwards. Thin shaly break near base forms a small terrace.	75.0	72.0

Limestone, buff and gray streaked, nodular weathering, rough platy. Weathers very buff to rusty on bedding planes.	45.0	27.0
Limestone, buff to grap weathering, nodular, somewhat platy to laminated, hackly weathering upwards.	27.0	

Mount Whyte formation

The youngest faunule—*Solenopleurella-Thompsonaspis* — found in the formation occurs at fossil localities in a gorge cut about twenty feet below the level of the dip slope of Sunwapta Peak.

Locality F. 12

Solenopleurella ? sp.
Thompsonaspis obscura Deiss

Locality F. 13

Thompsonaspis obscura Deiss
"Agnostus" sp.

The position of this fossil horizon in the stratigraphic section is estimated, from a cross-section drawn normal to the strike through the locality, to be within several hundred feet of the top of the formation. It occurs in a section of interbedded green shales and dark-gray limestones. A species of *Glossopleura*—*Glossopleura* cf. *G. prona* Resser —is present about 500 feet below the top of the formation on the north extension of Sunwapta Peak (F.9). It is found in platy, blue-gray, buff-weathering limestone underlain by slightly schistose green shale. Close to this horizon Sunwapta Peak formation beds tend to break down into a scree composed of pink-weathering, fine-granular, dolomitic limestones and gray, hackly-weathering limestone. Branching fucoids are characteristic of this position in the formation. *Albertella bosworthi* Walcott occurs within 200 feet of the base of the formation on the ridge above Jonas Creek campsite (F.1.).

Sunwapta Peak formation is a lithologically variable unit characterized by a series of profound facies changes occurring between its two well-defined and mappable formational boundaries. The writer attempted to map a buff dolomite "member" of the Sunwapta Peak formation early in the field season. This plan introduced serious difficulty in reaching reasonable interpretations of structure; later fieldwork revealed that the "member" was a secondarily formed unit with irregular boundaries. The contact between the dolomite "member" and Sunwapta Peak gray limestone migrates vertically as much as fifty feet over horizontal distances of a few hundred. F. Rasetti describes similar occurrences of interfingering limestone and dolomite in the Cathedral formation to the south[22] (p. 65). Formerly the Cathedral was differentiated into a lower Ptarmigan limestone formation and an upper Cathedral dolomite formation. F. Rasetti's excellent work has demonstrated the invalidity of the Ptarmigan based on this distinction between limestone and dolomite, and he places this section of mixed lithology wholly within the Cathedral formation. The Sunwapta Peak formation contains dolomite associated with dark blue-gray, argillaceous, knobby-weathering limestone beds near the mouth of Beauty Creek. The dolomite is cream-white to light-buff in color, and



PLATE XIV.

North face of Replica Peak (9,167 feet).

ranges from pure to calcareous. It is mostly medium-grained with maximum-sized crystals of three millimeters, and has local inter-crystalline porosity. Molar-tooth structures, similar to those described by R. A. Daly[7] (pt. 1, p. 175, pl. 22) in dolomites from Mount Eisenhower (Castle Mountain), are found in banded dolomites along the highway two and one-half miles north of the mouth of Beauty Creek. The banding in these dolomites results from alternating white, coarsely-crystalline, porous dolomite and medium-gray, finely crystalline, dense dolomite. A clean, white, coarsely-crystalline dolomite contains small aggregates of pyrite crystals in large inter-crystalline cavities at an altitude of 5,680 feet on Beauty Creek. Dolomite on the dip-slope hill between the two main forks of Beauty Creek is light-gray, dense, composed of crystals ranging from 0.2 to 0.8 millimeters in length, and rich-buff almost flesh-colour weathering. Striking the rock with a hammer results in an odor similar to that given off when flint is struck with steel. However, thin sections show no evidence of silicification. The dolomite is calcareous, cream to white, with local light-buff patches, and flesh-color weathering, tight, and contains crystals ranging up to 0.75 millimeters in length, on the ridge above Jonas Creek campsite at an altitude of 8,250 feet. Sunwapta Peak formation dolomites in Le Grand Brazeau are identical lithologically with those in the vicinity of Beauty

Creek. These are found on a ridge, which runs from under Coronet Glacier southward, and are light-buff and white in color, light-buff and granular weathering, and consist of crystals ranging up to three millimeters in length.

Dolomite facies are not alone in increasing the difficulty of tracing Sunwapta Peak formation. Local argillaceous phases and interbedded shale lenses are distributed throughout the unit. It is notably more shaly on the north extension of Sunwapta Peak massif than elsewhere in the area. On Tangle Ridge it is predominantly a limestone sequence. Farther south, near the head of Sunwapta Canyon, J. A. Allan found fossiliferous[2] p. 114) bluish-gray, thin-bedded and shaly limestone beds which he tentatively correlates with the Stephen formation of Bow River valley section. This facies was found on Sunwapta Peak poorly developed, but not on Tangle Ridge. It is probable that all Middle Cambrian shale units above the Mount Whyte are limited laterally by gradational facies changes and pinch-outs.

Intraformational conglomerates occur in the upper part of Sunwapta Peak formation. They are present at an altitude of 7,640 feet on the ridge above Jonas Creek campsite at a locality immediately below a saddle which divided the ridge into two parts. The conglomerate contains boulders ranging up to ten inches in diameter, is green, and of schistose appearance. Perfect sheeting cuts through the component boulders and results in an extensive, smooth, dip slope.

UPPER CAMBRIAN

TANGLE RIDGE FORMATION

The new formational name Tangle Ridge is assigned to a sequence of shale and limestone beds present between Middle Cambrian Sunwapta Peak formation and Ordovician limestone beds. The north ridge of Tangle Ridge between altitudes of 6,900 and 8,760 feet is designated as its type locality (PLATES VI, XVIII, XXI). The base of the formation is marked by the first introduction of green and ochrous shale beds above the limestone beds of Sunwapta Peak formation, and its upper boundary is chosen at the abrupt upward change from green shale to putty-colored, cherty, Ordovician limestone. The formation measures nearly 1,900 feet in thickness. The section was studied at the type locality, and a description of it follows:

LITHOLOGIC DESCRIPTIONS	THICKNESS	HEIGHT ABOVE BASE
	Feet	Feet
Shale, green, and interbedded limestones	470	1325
Shale, green, with lenses of limestone coquina ranging to six inches in thickness	305	1020
Limestone, dark-gray, shot with fine limonite specks, weathers very finely pitted. Yielded specimens of *Arapahoia* sp., *Arapahoia walcottae* Resser, *Arapahoia snowiensis* Howell and Duncan, *Maryvillia* cf. *M. alberta* Resser, *Dicellomus* sp.	25	995

Limestone, dark gray, contains one-quarter inch limonite spots, weathers pseudo-pisolitic	125	870
Limestone, grey with slight brown cast, irregular buff and dark-gray stripes, weathers nodular, becomes denser upwards	275	595
Limestone, very dark gray, extremely hackly weathering, tough, when acidized releases fine pebble-shapes sub-rounded inclusions	60	535
Shale, green and ochrous, friable	60	475
Shale, fine sandy, overlain by limestone, buff, slightly argillaceous, wavy-banded, buff-weathering	20	445
Base of more continuous outcrops		
Limestone, buff, argillaceous, platy	50	405
Limestone, gray-brown, dense, matt, wavy irregular banding	10	395
Sandstone and siltstone, very fine grained, calcareous, light rich-buff weathering, platy, becomes shaly, green, 25 feet above base	70	375
Limestone, dark-gray, matt, hard, dense, slightly shaly, trace of a nodular habit, one-quarter to five inch bandings, becomes very dark-gray and "slaty" at top	30	295
Obscured, probably shale	40	255
Limestone, light brown, dolomitic, dense almost matt, hard, one-half to eight inch beds	10	245
Shale, thin-bedded, green, with fossil rain imprints; and shale, red becoming buff, dolomitic, granular, massive upwards	40	205
Shale, variegated, green and red, splintery, platy, hard but friable, becomes very ochrous and locally mauve upwards. Interbedded with thin sandstanes, buff, platy, locally cross-bedded	205	0
Discontinuous outcrops		

Tangle Ridge formation is exposed also along Poligne Creek, where it is found to be sheared, drag-folded, and faulted (PLATE II).

Fossils occur in the formation at three localities (F.15, F.22, F.23). These yield assemblages representative of the upper *Cedaria* subzone[15] (p. 36) of the Dresbachian stage of the Upper Cambrian. Fossils collected at these localities are identified as follows:

Locality F. 15

Arapahoia sp.
Arapahoia walcottae Resser
Arapahoia snowiensis Howell and Dunctn
Maryvillia cf. *M. alberta* Resser
Dicellomus sp.

Locality F. 22

Arapahoia sp.
Arapahoia polita Resser
Arapahoia cf. *A. polita* Resser
Meteoraspis banffensis Resser
Bynumia sp.
Maryvillia sp.
Coosia sp.
Kormagnostus sp.

Locality F. 23

Kormagnostus cf. *K. esterius* Lochman
Modocia sp.

Only this single Upper Cambrian zone, restricted to the central portion of Tangle Ridge formation, is known in the mapped area. The formation occupies the same stratigraphic position as the Lynx formation of Mount Robson section, and is correlated tentatively with it. The Sullivan formation carries the *Cedaria* zone in the Siffleur River-Glacier Lake section, and is correlated with the fossiliferous portion of the Tangle Ridge formation. Green and ochrous shales at the base of the Tangle Ridge formation may represent the northern extension of Arctomys formation, and the post-*Cedaria* zone beds may be a shaly facies equivalent of the predominantly limestone Lyell formation. Exact correlations of the Tangle Ridge with Arctomys, Sullivan, and Lyell formations are not possible at present.

ORDOVICIAN

FORMATION A

J. L. Severson reports two Ordovician rock units—Mount Wilson quartzite overlying 1,500 feet of limestone—present in the Columbia Icefield area[23]. These are found also on Tangle Ridge, but are inaccessible due to their cliff-forming nature (PLATES VI, XVIII, XX, XXI). P. S. Warren states that on the ridge behind the Icefield Chalet the Upper Cambrian appears to be overlain directly by Lower Ordovician beds which yield "reasonably preserved examples of *Syntrophina*," and he points out that this section is very similar to that exposed on the Palisades at Jasper, where the Devonian lies directly on the Lower Ordovician.†

† Letter from Dr. P. S. Warren, University of Alberta, to R. D. Hughes, April 6, 1953.



PLATE XV.

Northeast fact of Sunwapta Peak massif, showing the type locality of Jonas Creek formation.

Formation A measures approximately 750 feet thick on the northwest face of Tangle Ridge. Formation A limestones (and dolomites) have three characteristics which are helpful in distinguishing them from others in the mapped area; they carry Ordovician fossils, contain black chert nodules, and weather a distinctive putty-gray color. The contact between Formation A and Tangle Ridge formation is exposed well on the northeast side of Tangle Ridge near the south flank of a glacier. At this place the basal ten feet of Formation A comprises light-buff weathering, locally oolitic, calcite-veined limestone overlain by dark-gray, conglomeratic limestone containing black chert grains. On the north ridge of Tangle Ridge Upper Cambrian green shales are abruptly overlain by medium-gray weathering Formation A limestones containing coiled gastropods and crinoid stems.

Near Tangle Creek the basal beds of Formation A are mostly dolomite with chert nodules, and form a sharp cliff. Green shale lenses and intra-formational green-shale conglomerate bands are found in the formation along switch-backs on the Banff-Jasper Highway.

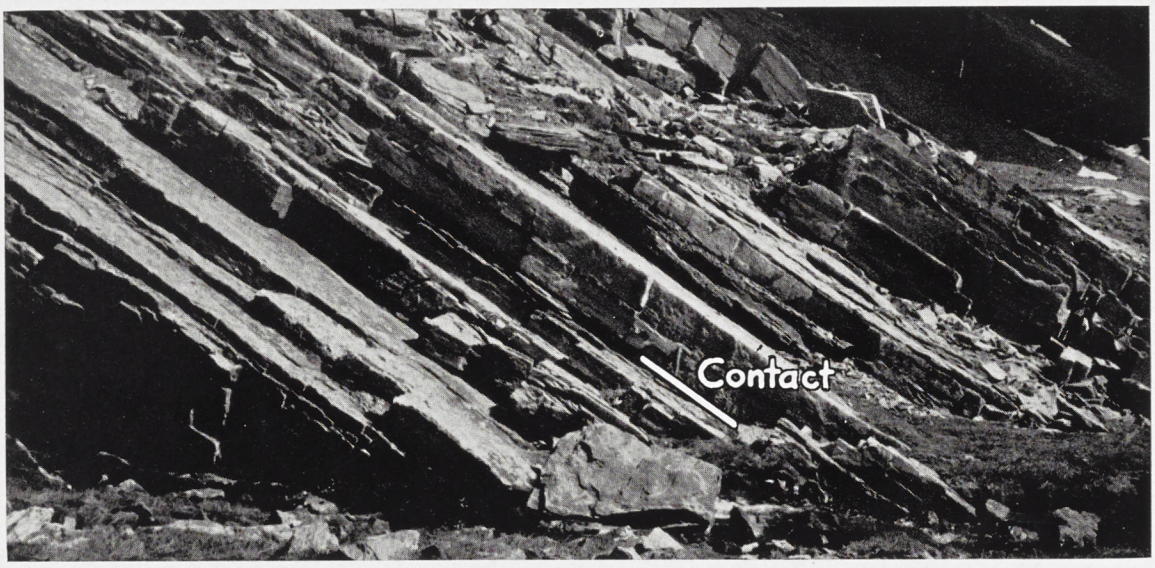


PLATE XVI.

Jonas Creek-Mount Whyte (Peyto member) contact. The arbitrary horizon used in Sunwapta area is indicated by the retouched line. Photographed in Trinity Lakes area.

MOUNT WILSON FORMATION (FORMATION B)

J. L. Severson traces the Mount Wilson formation north from its type locality to the Columbia Icefield area, and shows that it thins in this direction. The Mount Wilson is also shown by him to be unconformably overlain in Sunwapta Pass by the "Halysites beds" to which a questioned Silurian age is assigned.[23]

The Mount Wilson is overlain by Devonian strata in Sunwapta River area. Paleontologic evidence of the age of the Mount Milson is lacking. Severson suggests that it correlates with the Wonah quartzite of the Sinclair Canyon section in Brisco-Stanford Ranges. The stratigraphic relation of the Wonah and Mount Wilson quartzites has been discussed by C. D. Walcott as follows:

> Both quartzites are superadjacent to Canadian Formations; the Wonah is above the Glenogle graptolite shales and the Mount Wilson above the Sawback limestones, but the Wonah quartzite is overlain by a Silurian limestone and the Mount Wilson quartzite by a Middle Devonian limestone. With our present information I think the Wonah quartzite represents the sands of the transgressing Silurian sea and the Mount Wilson quartzite the sands of the transgressing Devonian sea, and the Wonah should be referred to the Silurian, and the Mount Wilson to the Devonian[27] (p. 209).

The writer concurs with Severson in assigning an Ordovician age to the Mount Wilson, but cannot agree that it is the same lithologic unit as the Wonah quartzite. Further field regional studies are necessary before the exact stratigraphic position of each can be known.

The Mount Wilson formation crosses Tangle Creek above the highway bridge but is partially obscured. An approximate thickness of ten feet is estimated for it at this locality. The formation is mostly uniform, white, buff-weathering quartzite composed of tightly interlocked quartz grains ranging from 0.3 to 0.5 millimeters in diameter.



PLATE XVII.

Mount Whyte-Sunwapta Peak contact. Photographed on the west side of Tangle Ridge. The contact is indicated by the letter "x."

The formation also crops out on the northeast branch of Tangle Creek at an altitude of 7,500 feet. In this outcrop area the quartzite is fine-grained, tight, rusty-to-buff weathering, and contains fine scattered pyrite crystals. Since the strata are exposed on a slope nearly parallel to their angle of dip it is difficult to measure the formational thickness. A thickness of nearly twenty feet is computed for the Mount Wilson by the addition of bed-by-bed measurements.

In the north part of Tangle Ridge the contact between Ordovician and Devonian systems is at an inaccessible position on a cliff, and cannot be examined. Consequently it is not known whether the Mount Wilson formation, which thins northward, disappears before reaching the north face of Tangle Ridge.

DEVONIAN

DEVONIAN UNDIVIDED

Devonian rocks are found in the trough of Tangle Ridge synclinal structure, and capping Tangle Ridge. The Devonian beds vary in lithology; but are mostly shaly limestone, limestone and dolomite. They are abundantly fossiliferous, and the south-

central slope of Tangle Ridge is an excellent fossil-collecting ground. Corals and stromatoporoids are the most common fossils. Brachiopods and cephalopods also are found. A collection of fossils made by Ralph Bailey from this slope have been identified by P. S. Warren as follows:

Disphyllum cf. *D. catenatum* Smith
Disphyllum cf. *D. densum* Smith
Disphyllum cf. *D. colemanense* Warren
Phillipsastrea whittakeri Smith
Thamnopora cf. *T. polyforata* Schlotheim
Aulopora cf. *A. repens* Edwards and Haime
Stromatoporoid, undet.
Productella sp.
Leiorhynchus ? sp.
Elytha undifera (Roemer)?
Atrypa cf. *A. missouriensis* Miller†

Warren dates this fauna as Upper Devonian, and notes "The horizon suggested by this collection is the Mt. Hawk formation and probably fairly low down in the unit as your collection does not contain a *Spirifer whitneyi*."

Dark-gray, argillaceous limestone on the summit of Tangle Ridge contains a species of *Tentaculites* in large numbers.

It is impossible to confuse Devonian with Ordovician strata in the mapped area because distinctive faunas are present in each.

PLEISTOCENE

All surficial deposits in the area are assigned a Pleistocene age because "near-Pleistocene" conditions prevail in this mountain region. The deposits are of three main types as follows: moraines, alluvium, and colluvial deposits. Fresh morainal deposits are found at termini of active Alpine glaciers. Alluvial deposits, ranging from fine silts to boulder gravels, are distributed in stream channels, but alluvial terraces are rare. Colluvial deposits are present as scree slopes, talus fans, and talus girdles. These "Pleistocene" deposits have fresh natures, lack cementation, and show few effects of decomposition.

STRUCTURAL GEOLOGY

Sunwapta River area lies within a single structural province—the central Rocky Mountains. Two structure units are found in the mapped area, and are named as follows: Tangle Ridge synclinal structure and Coronet Mountain anticlinal structure. These are genetically related.

The axis of Tangle Ridge synclinal structure trends southeastward from Tangle Ridge summit through Nigel Peak (10,535 feet) to Mount Coleman (10,262 feet). It plunges in this direction, and the base of the Mississippian is found on Nigel Peak. At Sunwapta Falls, twenty miles northwest of Tangle Ridge, Sunwapta Peak formation limestones underlie the valley floor at an altitude of 4,500 feet, and Jonas Creek formation quartzites on Endless Chain ridge form the east limb of a synclinal structure immediately to the east. On strike, eleven miles farther northward Jonas Creek quartz-

† Personal letter from Dr. P. S. Warren to Mr. Ralph Bailey.



Tangle Ridge panorama photograph by Clair Brown, Solon, Iowa. Rick unit contacts, fossil horizons, and mountain names are indicated by letter symbols as follows: MW Mount Whyte formation, T/S Sunwapta Peak-Tangle Ridge contact, O/T Tangle Ridge-Ordovician contact, D/O Ordovician-Devonian contact, C *Cedaria* zone, N Nigel Peak, W Wilcox Peak.

PLATE XVIII.



PLATE XIX.

South fork of Tangle Creek. Photograph shows the south extension of Tangle Ridge synclinal structure. Devonian limestones occupy the trough.

ites are folded into a synclinal structure on Mt. Kerkeslin. This alignment of synclinal structures over a distance of sixty miles from Nigel Peak to Mt. Coleman suggests a single structural unit, though this is not proven.

The west limb of Tangle Ridge synclinal structure has steep east dips ranging up to seventy-five degrees on Tangle Ridge, and is so profoundly faulted that the entire Tangle Ridge formation is cut out near Tangle Creek. The axial plane dips westward under the summit of Tangle Ridge, but eastward in the vicinity of Tangle Creek. Minor synclinal and anticlinal structures are associated with small parallel tear faults on the west flank, and their axes are obique to the axis of the main structure. They can not be explained with reference to the component direction of greatest shortening during the major orogeny, but suggest that later shearing movements were introduced. A few minor rolls and faults are found with axes parallel to that of the major structure, and have a common origin with it.

The east limb of the structure has a width of about seven miles, and involves the stratigraphic section from the Hector formation to the Devonian system. It has an average dip of twenty-five degrees westward, ranging from nine degrees near the axis at Stanley Falls to thirty-nine degrees on Sunwapta Peak massif. The dip angle increases northward, and reaches a maximum of forty-five degrees on Endless Chain Ridge. Faults are found in the east limb on the ridge west of Jones Creek, on a flat-iron flanking the north side of Sunwapta Peak, and on the northeast side of Tangle Ridge.

Sunwapta Peak formation is of abnormal thickness across the valley of the south branch of Beauty Creek. The simplest and most probable explanation for this is duplication of strata by faulting. The presence of a strike fault is suggested by the straightness of this branch of Beauty Creek, and although it was not located on the surface it is indicated on the accompanying geological map and cross-sections. Tangle Ridge synclinal structure is bordered on the east by Poboktan Creek thrust-fault trace.

Coronet Mountain anticlinal structure is located east of Poboktan Creek fault zone. Its axis was traced for a distance of eight miles. It is probably continuous for some distance to north and south, although not as persistent as that of Tangle Ridge synclinal structure.

As a general rule one can assign a common structural origin to adjacent folded structures with parallel axes in orogenic regions. Tangle Ridge and Coronet Mountain structures fit this case and it is reasonable to apply this rule to them. The probable

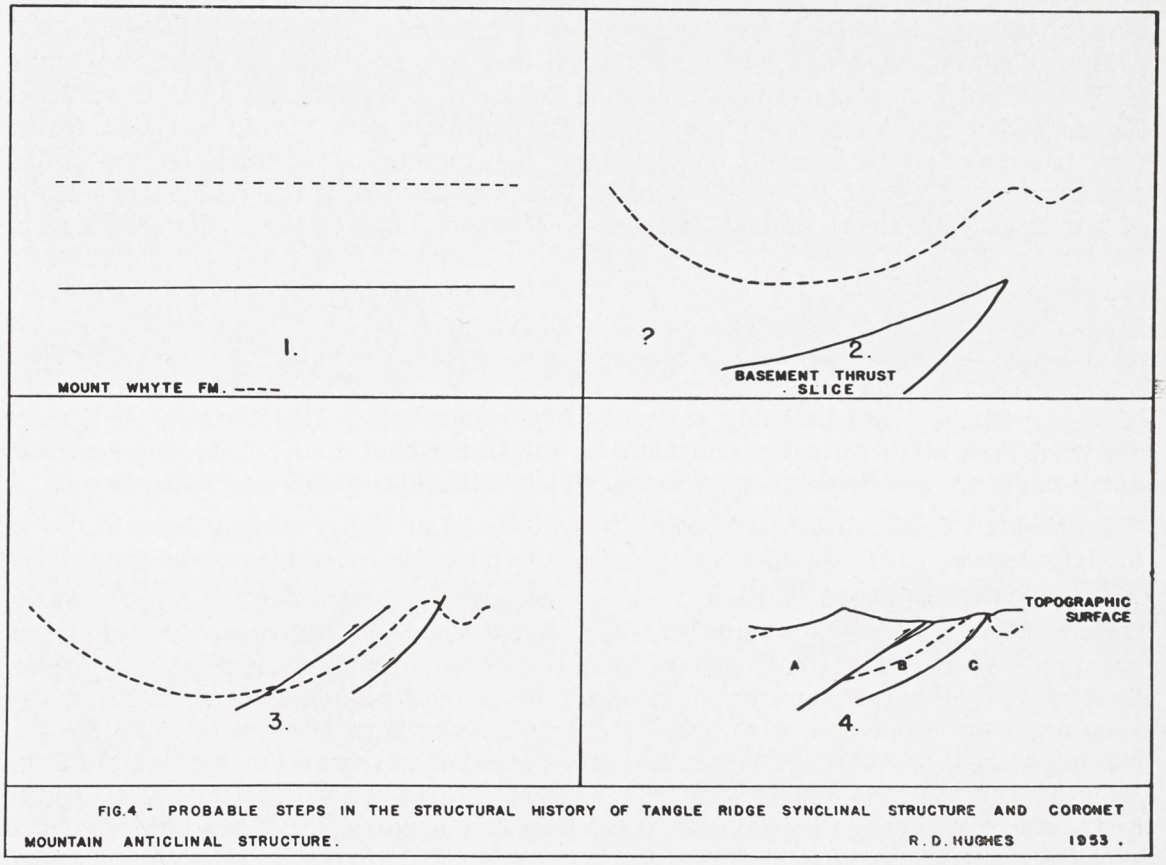


FIG.4 - PROBABLE STEPS IN THE STRUCTURAL HISTORY OF TANGLE RIDGE SYNCLINAL STRUCTURE AND CORONET MOUNTAIN ANTICLINAL STRUCTURE. R.D. HUGHES 1953.

steps in their development are illustrated graphically in figure 4. Primary and secondary steps show the folding of an originally flatlying sedimentary sequence into a western synclinal structure and an eastern anticlinal structure. In the third step additional compressive forces are shown to have resulted in the formation of transecting thrust-fault planes, which have been localized later into bedding-plane thrust faults. In the fourth step block A is shown to have ridden some ten miles eastward over block B, and this is held to represent the mechanics of the main back-limb thrust fault (Poboktan Creek fault) of the mapped area. Block A depicts Tangle Ridge synclinal structure; and blocks B and C represent Coronet Mountain anticlinal structure. The anticlinal structure is broken by a front-limb thrust fault east of the anticlinal axis in the open valley southeast of Coronet Glacier.

Jonas Creek, Mount Whyte, Sunwapta Peak, and Tangle Ridge formations are involved in the surface expression of Coronet Mountain anticlinal structure. A thin sheet of rocks of possible Ordovician age is found in the northern end of the mapped foot-

wall zone of Poboktan Creek fault. It is an unfossiliferous light-buff limestone with cherty inclusions and other characteristics common to Ordovician limestones of Tangle Ridge. However, the stratigrapic interval between the top of Sunwapta Peak formation and the fault-line trace is less than the known thickness of the Tangle Ridge formation, and hence it is concluded that the Ordovician system is faulted out.

Poboktan Creek thrust fault forms the structural boundary between Tangle Ridge synclinal structure and Coronet Mountain anticlinal structure. The fault-line trace is followed closely by the channel of Poboktan Creek where it flows northwestward, and by the southeast-flowing middle branch of Poligne Creek (PLATE XXIV). The basal gliding surface of the overthrust block is Hector formation shale. The block rode forward on shales and limestones of Tangle Ridge and Sunwapta Peak formation (PLATE XXIII). The fault plane is nearly parallel to beds in the Hector, but it truncates Tangle Ridge and Sunwapta Peak beds. The magnitude of Poboktan Creek thrust fault is not known, but a minimum figure can be estimated. Ten miles horizontal displacement would permit the 10,000 foot vertical displacement if the visible angle of dip of the fault plane is maintained at depth. However, dips of the fault plane and of the strata of Hector, Sunwapta Peak, and Tangle Ridge formations are approximately the same in any one cross-section. All three formations show strained conditions, and minor faults and drag folds related to the major overthrust are found in them. The largest drag-fold, associated with the major overthrust, occurs on the extremity of the south ridge of Replica Peak. Stress has been relieved close to the surface by local faults. Many are shallow and probably pass into folds downwards. The Hector shale is more distorted than other formations involved in the thrust-fault zone. It is doubtless that many faults are present in that formation which neither were seen nor mapped.

Poboktan Creek thrust-fault plane dips westward at angles ranging from forty-five to sixty degrees. It is shown in cross-sections to maintain these angles near the surface but it probably flattens at depth.

The development of the fault plane could have taken place in one of several different ways: either it could have developed and persisted as an oblique transecting plane; or it could have passed upwards in a series of steps by cutting competent beds at high angles and incompetent ones at low angles; or it could have been initiated by the displacement of Hector beds so that they were brought into apposition with Upper Cambrian by a major block-fault movement, followed by the overthrust of the Hector to the east. An origin by the second alternative does not appear likely since anticlinal and synclinal rolls are lacking in the over-thrust sheet. The third alternative is considered improbable because block-faulting is usually a result of tensional conditions, and the mapped area is one of predominant compressional conditions. It is concluded that the first alternative is the most likely. Major thrust-faulting is associated with an oblique transaction of foot-wall formations along an almost smooth fault plane in Poboktan Creek fault[9] (pp. 79-97).

Minor structures are not symbolized on the accompanying map. These are distributed throughout the area. Fracture cleavage is developed locally, particularly where strata are distorted by faulting and tight folding. Sunwapta Peak formation, especially the lower dark-gray limestone section, shows strong susceptibility to jointing. Small plunging anticlines and synclines occur on the west limb of Tangle Ridge synclinal structure, and are discussed previously in this chapter.

HISTORICAL GEOLOGY

Measured descriptive stratigraphic colums are a necessity for an adequate discussion of historical geology. Stratigraphic columns from a faulted mountain region are

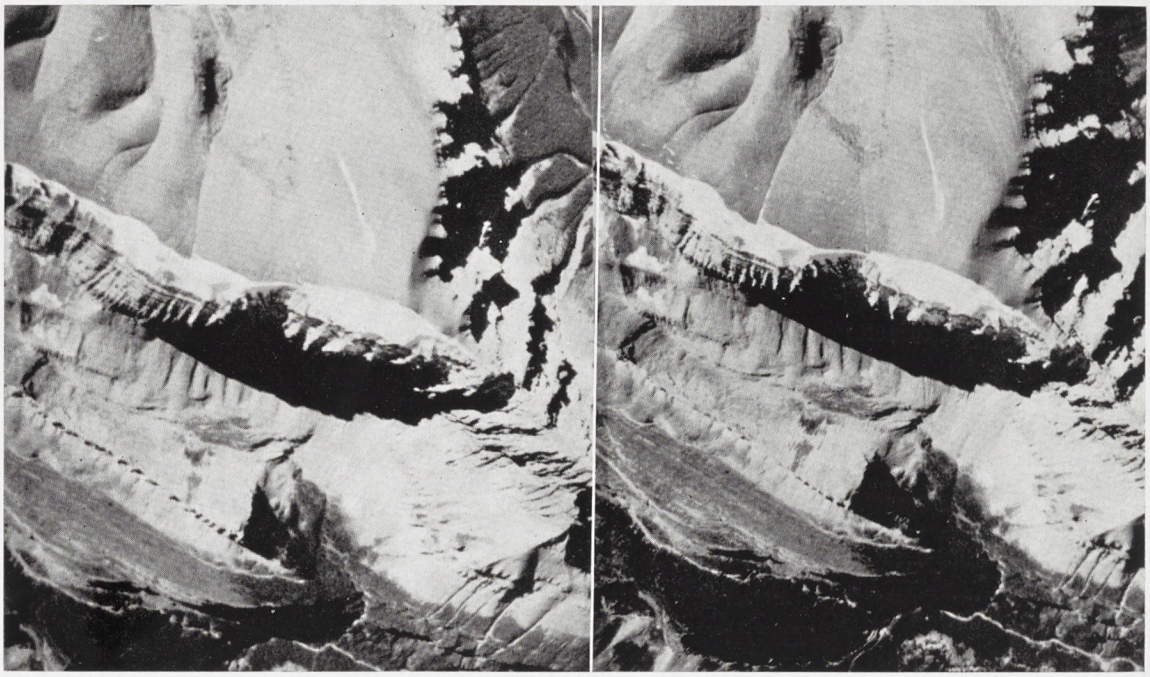


PLATE XX.

Tangle Ridge and Beauty Creek valley. The top of this stereoscopic pair is south.

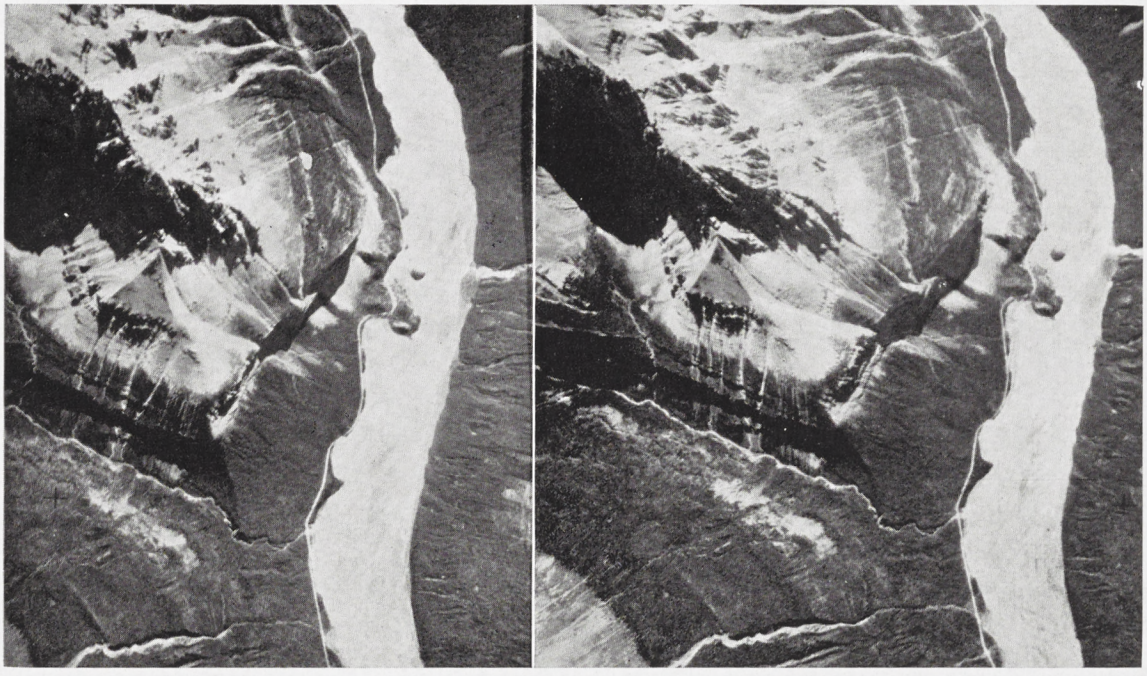


PLATE XXI.

Tangle Ridge and the southwest corner of Sunwapta Peak. The top of this stereoscopic pair is south.

composite by nature. They are of less value than continuous sections under any circumstance and especially so if facies changes are present. For example, an Upper Cambrian offshore section if brought by overthrust into the proximity of a Middle Cambrian nearshore facies is apt to be combined with it.

Lower Paleozoic sections from Mount Eisenhower (Castle Mountain), Field map-area, Brisco-Dogtooth area, Siffleur River, and Mount Robson in the Canadian Rocky Mountains are recorded in the literature on the region. The descriptions and interpretations of these sections are undergoing constant revision as more work is done upon them.

F. Rasetti[21] (p. 1219) writes:

> The . . . Cathedral dolomite is represented at certain localities by almost pure calcareous beds; the "Ptarmigan" limestone is only the lower, undolomitized portion of the Cathedral and must be suppressed as a formation . . . Revision of the classic section on Mt. Stephen shows the inaccuracy of Walcott's work. The character of the sediments undergoes a deep change within the mountain; the entire Cathedral formation grades laterally from dolomite at the northeast to shale and thin-bedded limestone at the southwest. Walcott's composite section does not represent actual conditions at any one locality.

The section given by J. A. Allan[1] (p. 60) for Field map-area requires restudy. The Chancellor shale is faulted against the Sherbrooke and was added on, in error, as part of the Upper Cambrian section. The Chancellor shale, Ottertail limestone, and the lower part of the Goodsir formation is probably equivalent to all the Middle and Upper Cambrian of the Mt. Burgess-Sherbrooke section.† The Ottertail may be in part equivalent to the Paget formation.

C. S. Evans' report of Brisco-Dogtooth map-area includes a chart of stratigraphic divisions[11] (p. 116A). Early Lower Cambrian is shown to comprise Fort Mountain and St. Piran formations. Lower Mount Whyte (Peyto limestone) of the Bow Valley section is replaced by the Donald formation, which is 1,500 feet thick, and contains an olenellid and mesonacid fauna. The Donald is overlain by the Canyon Creek formation of Middle and Upper Cambrian age in the Dogtooth Mountains. In Brisco Range the Canyon Creek equivalent is the Jubilee formation, which is overlain by McKay Group of Cambro-Ordovician age.

Widely different interpretations of the Mount Robson stratigraphic section are recorded, based on studies by C. D. Walcott in 1912 and 1913; and by L. D. Burling in 1915 and 1917. Burling's is accepted as the more representative since it supplements Walcott's pioneer work.

The Siffleur River Lower Paleozoic section, comprising St. Piran to Lyell formations, is the closest measured section to Sunwapta River area.

The aforementioned sections are of little value for the construction of regional paleogeographic maps except for Lower Cambrian time. It will be premature to attempt to relate the early history of the Cordilleran geosyncline until careful re-studies have been made of Cambrian stratigraphic sections. A generalized review of regional historical geology follows, but it is based on minutae of field data, and consequently is held to be largely speculative.

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† Letter from Dr. P. S. Warren, Department of Geology, University of Alberta, to R. D. Hughes, May 13, 1952.

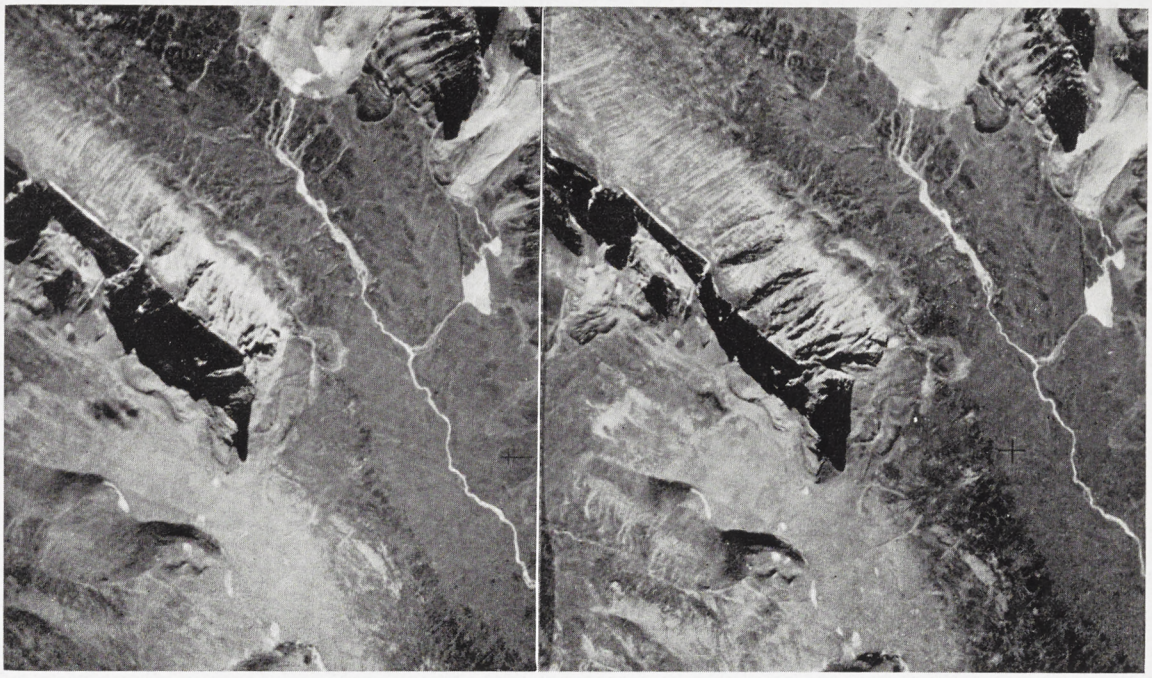


PLATE XXII.

Jonas Pass, an isolated quartzite mountain, and Hector formation hills along Jonas shoulder. The top of this pair is south.

The nature of the early Cordilleran gosyncline, and the Pre-Cambrian-Cambrian boundary problem has been discussed in the section on the stratigraphy of Jonas Creek formation. However, it may be well at this point to review briefly the two main hypotheses regarding the type and site of the basin of deposition. One presumes a geanticline in the position of the present Selkirk Mountains supplied sediments to the Rocky Mountain geosyncline to the east. The second hypothesis presumes a migrating geosyncline moved from west to east across the region, with most of the sediment derived from an eastern shoreline of submergence. In either case the site of deposition appears to have been a broad marginal shallow sea.

The oldest rock unit exposed in the area—Hector formation — has characteristics suggesting deposition on a rather stable platform with an unstable oldland source on which severe erosion was prevalent. Earthy, probably drab-colored muds and interbedded pebble gravels were deposited in the basin. The origin of constituent white quartzite pebbles in the Hector conglomerates is unknown. Local green and red colorations in phyllitic phases of the shale beds are secondary effects associated with metamorphism. There is no evidence that these shales were laid down in bodies of fresh water as suggested by C. D. Walcott, and the lack of preserved fossils appears to be the result of an absence of shelled forms in the sea.

In late Hector-early Jonas Creek time, the eastern shoreline was uplifted and marginal Hector-shale beds were stripped. Deposition of platform pure-quartz and quartz-iron-oxide blanket sands followed. Conditions remained uniform into late Jonas Creek-early Mount Whyte time, except for a short period of instability in the source region during Lake Louise time. C. S. Evans reports an unconformity between the Horse-

thief Creek (Hector) series and the Fort Mountain formation in the Dogtooth Mountains[11] (p. 118A). V. J. Okulitch[19] (p. 7) found that in the Selkirks the uppermost member of the Horsethief Creek series is variable in thickness possibly owing to erosion before the deposition of the Hamill series, and he suggests "a possibility that an erosional unconformity separates the Horsethief Creek from the overlying Hamill series." In Sunwapta River area the Hector-Jonas Creek contact is gradational, and sedimentation appears to have been continuous. Fluctuating conditions in the source region resulted in an upwards transition from shales to sandstones. Cross-bedding in Jonas Creek formation at a few places indicates currents were directed from east to west. Minor submarine (?) volcanic activity in late Jonas Creek time resulted in the dispersal of basic igneous materials at several places in the Cordilleran geosyncline.

Cambrian time began with the deposition of the platform limestones of the lower member of Mount Whyte formation (Peyto limestone) in Sunwapta River area. This thin, but widespread, member is present in the front ranges of the Rocky Mountains in Bow Valley where it has been included in the Cathedral formation[5] (p. 623) westward in Field map-area and north to Sunwapta River area. To the west in the Dogtooth Mountains this member is replaced by its equivalent—Donald Formation. It is represented by the Mural limestone of L. D. Burling in the Mount Robson district. Thickening of the Peyto limestone and its equivalents to north and west indicates more rapid subsidence in these directions. V. J. Okulitch has suggested that the Pre-Cambrian Badshot Limestone of the Lardeau area may correlate with the Cambrian Donald formation of the Dogtooth Mountains (figure 3).

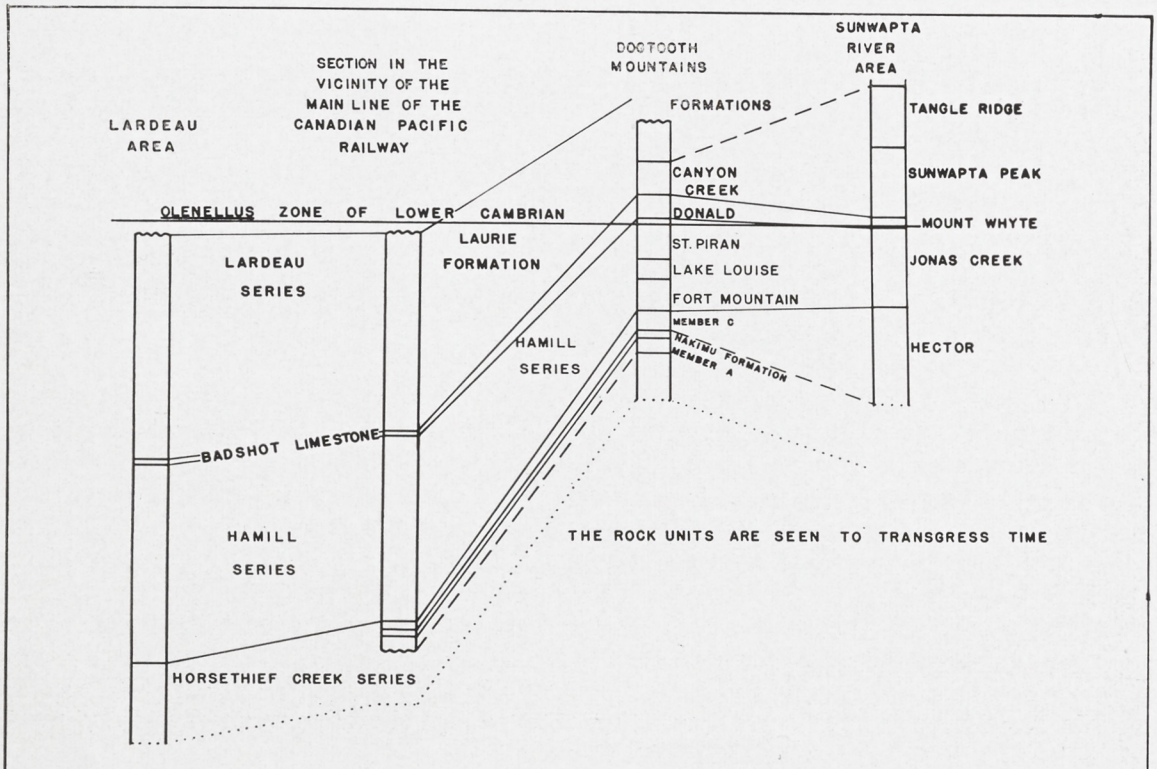


FIG.3 - PROBABLE CORRELATION CHART OF FORMATIONS, USING OLENELLUS ZONE AS A REFERENCE HORIZON
AFTER V.J. OKULITCH (1949) IN PART.

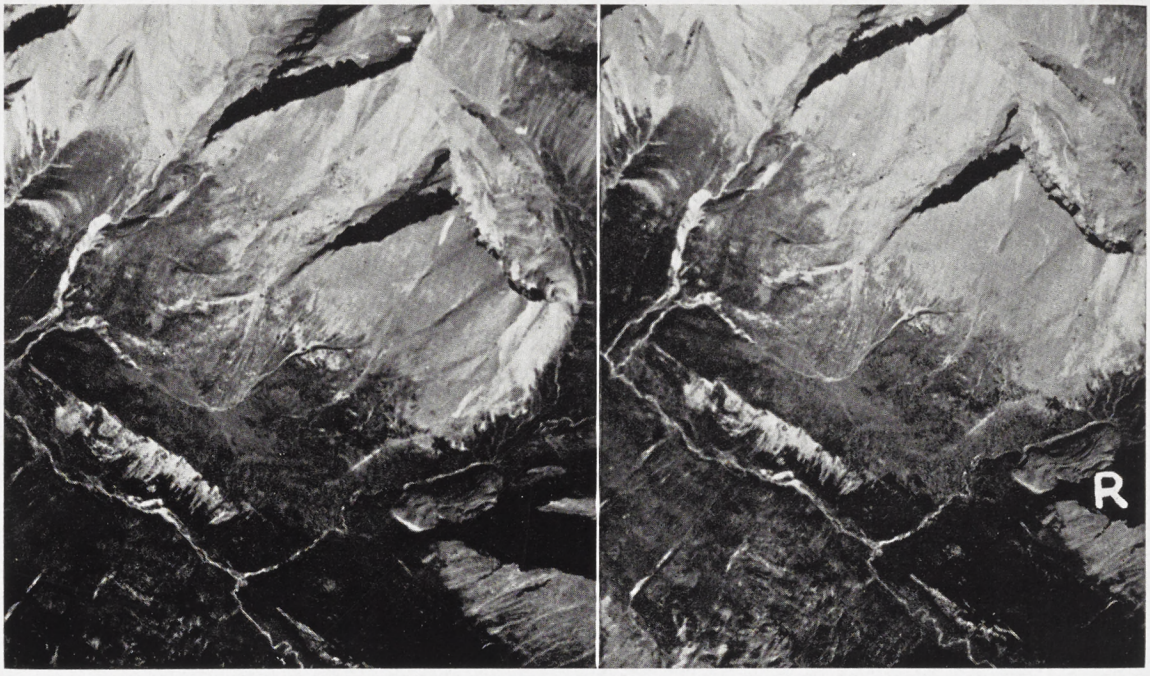


PLATE XXIII.

Rock glacier indicated by the letter "R." This photograph also shows hogbacks east of Poboktan Creek and Poboktan Creek fault line trace on the same side. The top of this pair is north.

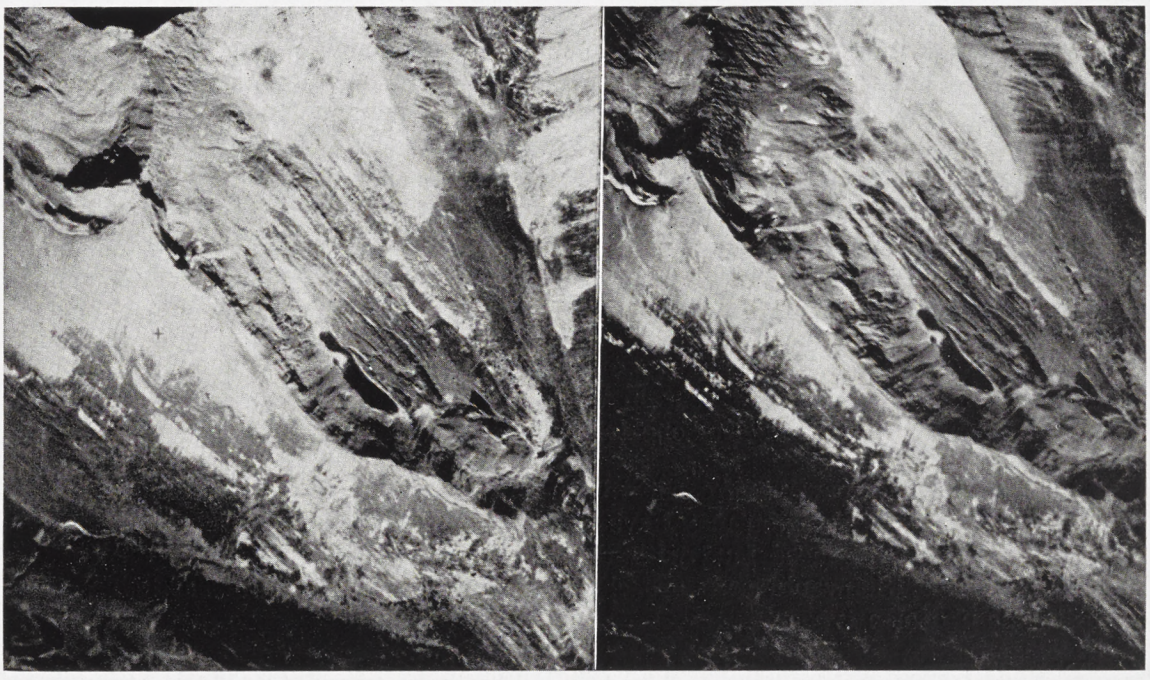


PLATE XXIV.

Replica Peak and the mountain to the east which it resembles. Poboktan Creek thrust fault separates them (see PLATE II). Top of this pair is north.

In early Middle Cambrian time platform conditions prevailed in the region, and there is a distinctive lack of evidence of strong positive movements in the source oldlands. Green shale beds of Mount Whyte formation were distributed eventually throughout most of the central Rocky Mountain region during this interval of time. They appear to have been formed by the deposition of clay minerals on a shelf adjacent to a slowly disintegrating oldland. The color of this shale is a result of an abundance of secondary chlorite crystals. Apparently strong currents were nearly absent because current-accumulated lenses of debris are absent in this section except in its uppermost part.

In late Mount Whyte time the upper colitic limestone member was deposited under the same platform conditions as the middle green shale member. It was laid down in shallow marine waters. Evidence of abundant life is found in it. Trilobite moults and tests are concentrated into small mounds by currents. These are cemented and replaced by carbonates, and form dense limestones, which show fossil outlines on joint and bedding-cleavage planes. Beds of gray and green shale are intercalated in the limestone member, probably as the result of rapid changes in the source oldland.

The seaways had deepened and geosynclinal limestones and shales were being deposited by early Sunwapta Peak time. The Sunwapta Peak formation is the equivalent of the Cathedral-Stephen-Eldon sequence, and probably occupies the same stratigraphic position as the Chetang-Tatei-Titkana section of Mount Robson area. Thickness measurements of these equivalent sequences show thinning from Field eastward to Eisenhower Mountain; and northward to Dogtooth Mountains and Supwapta River area. The sequence thickens northward from Sunwapta River area to Mount Robson. It is predominantly limestone, but muds (shales) were introduced by fluctuations in the shorelines. Dolomitization appears unrelated to primary sedimentation, and the Eldon dolomite was deposited in essentially the same seas as were Cathedral limestones. Environmental conditions favorable to abundant life of soft-bodied forms, as well as to trilobites and brachiopods, were present in the Middle Cambrian geosyncline.

Upper Cambrian sedimentation began with the deposition of muds, which indicate a probable subjection to sub-aerial exposure by their red and green colors. These muds are believed to have been widespread banks that reached from Bow Valley, as the Arctomys lense, through Sunwapta River area, as basal Tangle Ridge formation, to Mount Robson area, where the basal beds of the Lynx formation contain ripple marks, mud cracks, and casts of salt crystals.

The seas gradually cleared, and by early Dresbachian time limestone deposition was predominant again. Limestone beds in Tangle Ridge, Sullivan, and Lynx formations yield rich assemblages of *Cedaria*-zone trilobites.

A return to mud seaways of earliest Upper Cambrian time took place after early Dresbachian time. The region may have stood high for a short interval, but limestone seaways once more replaced mud with the advent of the Ordovician period. Ordovician limestones of Sunwapta area are characteristically cherty and appear to have been deposited as platform types.

Devonian seas were muddier and their limestones are interbedded with shales. Platform conditions are indicated by an abundant distribution of reefs in that part of the Paleozoic section. Sedimentation continued into late Paleozoic time[4] but the record has been lost in the Sunwapta River area by post-Laramide erosion.

It is possibly only to speculate on the origin and mode of formation of the Rocky Mountains until regional structural conditions, including those in the Rocky Mountain trench and foothills, are known better. Rather diverse explanations for the structural origin of the mountains are given in the abundant literature on this subject. Proponents of one school of thought consider Rocky Mountain structures the result of compressive forces directed from the west. Other geologists advocate a hypothesis of mountain folding as a result of basement faulting, and present good evidence for their conclusion. G. M. Lees recently has discussed foreland folding in the Canadian Rocky Mountain foothills, and postulates basement thrust-slice faulting as a major factor in their development[13] (pp. 21-23).

The fact that late Mesozoic and Tertiary strata are absent from the central belt of the mountains obscures evidence of the sequence or orogenic movements. Two separate periods of orogeny are indicated by structure studies of the Rocky Mountain foothills. In Turner Valley area, Laramide structures are superimposed on late Jurassic (?) folds. The earlier deformation is responsible for the growth of the Selkirk Mountains. O. A. Erdman[10] records the discovery of two periods of deformation in the foothills of Alexo-Saunders map-areas: a middle Carboniferous-pre-Jurassic epeirogeny followed by a post-Paleozoic-pre-Pleistocene orogeny. Most fault planes in the Rocky Mountains and their foothills dip westward, as if either eastern overthrusting or western underthrusting are present. However, in the Van Horne Range of the western slope of the Rocky Mountains some fault planes dip eastward.

An alternative possible explanation of the origin and mode of formation of the Rocky Mountains herein is introduced for the reader's consideration. This hypothesis is based on the premise that only the roots of Alpine-type folded mountains remain in the central Canadian Rockies. The most significant regional feature of the Rocky Mountain unit is the fact that it truncates Purcell Range, Selkirk Range, and the mountain ranges west of the Columbia Lakes, along the Rocky Mountain trench. The foregoing ranges disappear under the Rocky Mountains, which are probably a gigantic overthrust to the west. The mechanics involved in such major overthrusting are difficult to explain and I cannot pretend to do so in the present paper. The Rockies may have been dragged westward by deep crustal movements and buffered so effectively by the western ranges that folds piled up and became resolved into fan and backward folds. An alternative possibility to be considered is the derivation of fan-folds due to the isostatic rise of a tectogene. Possibly, underthrusting of the whole region west of the Rocky Mountain trench may have occurred.

Paleocene Porcupine Hills formation is a thick belt of molasse carried eastward by streams flowing off the uplands of the young Rocky Mountains, and deposited in east-flanking lowlands. Remnants of it are found in the Rocky Mountain foothills and in outliers on the plains. This molasse deposit is traceable east where it occurs in the Paleocene Turtle Mountains formation, the Eocene Swift Current formation, the Oligocene Cypress Hills conglomerate, and in the Miocene Wood Mountain formation. A Tertiary molasse deposit, probably associated with a late Upper Cretaceous or Paleocene cycle of erosion, is found in the Rocky Mountain trench.

PHYSICAL FEATURES, CLIMATE, FLORA, AND FAUNA

PHYSICAL FEATURES

The Sunwapta River area is in an interrupted late early stage of an erosion cycle. Its natural features, typical of Rocky Mountain physiography, comprise mountains, ridges, valleys and stream channels.

Altitudes range from 4,900 feet in Sunwapta River valley to 10,875 feet at the summit of Sunwapta Peak (PLATE I). More than one-half of the original mass above 4,900 feet has been removed by erosion from the region.

The physiographic pattern can be discussed most profitably if reference is made first to streams and valleys; next to hills, ridges, and mountains; and lastly to glaciers and glaciation.

Three important stream channels present in the area are as follows: Sunwapta River, Poboktan Creek, and Jonas Creek.† These are found in synclinal troughs, along shear zones, and at the contact of soft with hard beds.

Sunwapta River occupies a synclinal trough between Sunwapta Falls and the mouth of Beauty Creek. Above Beauty Creek the river is slightly diverted to the south as it heads back around Tangle Ridge. Throughout this distance the valley is flat bottomed. Walls are concave upward to altitudes of 9,000 to 10,000 feet on the east side of the valley, and to over 10,000 feet on the west side. Subsequent streams have cut back deeply into the western valley wall, and this side is more dissected than is the eastern wall.

It is questionable whether Sunwapta River valley was filled to a significant depth with a late Wisconsin glacier despite its broad U-shaped cross-section. Striae and other acceptable evidence of glacial grooving are not observed on bedrock walls of the valley. Lateral and terminal moraines are absent in the valley. An additional indication that valley glaciation by-passed Sunwapta River valley is furnished by a south-facing open cleft on the west side of Tangle Ridge. The cleft appears too large to be a recently developed feature. The down-hill direction in the valley is northward, and this cleft is situated in such a way that it would have been removed by scour by a flowing valley glacier. It is concluded that either glaciation was absent or that the cleft is much younger than it appears.

The water of Sunwapta River has its principal origin in the Columbia Icefield. As the river approaches the mapped area it is confined by a canyon opposite the north end of Wilcox Peak. Even below where the canyon walls open out the river remains restricted to a single winding channel as far as the mouth of Tangle Creek. Thence braided flood-plains replace the channel and extend for six and one-half miles to the north. Finally, Sunwapta River again occupies a single nearly-straight channel for the remainder of its course through the mapped area.

Two flood-plain types are found along the course of Sunwapta River. Bar plains with braided low-water channels are present from a point two and one-half miles above to four miles below the mouth of Beauty Creek. Covered flood-plains in combination with dominant meander plains occupy several short stretches along the course from Jonas Ridge to Endless Chain Ridge.

At present the river nearly has lost contact with bedrock along most of its course and little planation of pre-glacial strata can be observed. This is a result of over-burdening by numerous, though short, tributaries. The valley was first formed in Tertiary time and gradually excavated from then to the present. Incompetent beds and zones

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† Sunwapta is the Stoney Indian word for "turbulent river" and "river of the whirlpool." Poboktan is the Indian word for "owl." Jonas was a Slavey Indian who hunted the region in the early 1890's.

of structural weakness both have been factors in determining the river's location. Running waters, not glaciers, have been the agency most responsible for Sunwapta River valley.

Above their junction Poboktan Creek and Poligne Creek, and the latter's east branch flow very close to a fault trace (PLATES II, III). Beds along the trace have been fractured and sheared locally. This structural weakening has left the zone more susceptible to erosion than surrounding undisturbed rocks. Both Poboktan Creek valley and Poligne Creek valley have characteristics associated with derivation by stream erosion.

A low divide, beyond Maligne Pass, separates the west branch of Poligne Creek from the headwaters of Maligne River (PLATE IV). This branch of Poligne Creek, although only ten feet wide, occupies a broad shale valley in its upper part. In its lower reaches, it is deflected eastward by pebble-band buttresses flanking a conical Hector shale hill east of the south extremity of Endless Chain Ridge. Thence it swings into and follows along a strip of Upper Cambrian limestone and shale beds. Apparently, when impervious plastic Hector shales flowed, fracture openings in them nearly were closed by distorting forces. On the contrary, relatively-competent Upper Cambrian limestone beds disintegrate on the surface, when fractured, and provide potential channelways which Poligne Creek follows.

The upper course of Poboktan Creek lies between banks and hills of Hector shale. Loops are entrenched to shallow depths for short distances where the creek meanders. Examination of aerial photographs shows that abandoned meander scrolls are lacking. The surmise that recent rejuvenation has taken place at this locality, based on the above-mentioned observations, is supported by the situation of a shale spur which extends nearly across the valley floor. Lateral planation has not had time to become important since the rejuvenation.

The quartzite formation of Endless Chain Ridge, Jonas Ridge, and their continuation to the south is twice crossed by water gaps within the mapped area. There is no evidence that either gap is super-imposed. The lower stretch of Poboktan Creek cuts across the quartzites for a distance of more than two miles. Jonas Creek intersects the ridge between six and eight miles above its mouth and isolates a rugged quartzite mountain on the east side of Jonas Pass (PLATES V, XXII). Aerial photographs of the area show two stages of the sequence followed in the cross-cutting of the quartzite-formation band. The earlier stage is observable in aerial photographs of Jonas Ridge opposite Jonas Creek camp site. At this place the divide is being narrowed by resequent streams. These have cut flatiron-type hogbacks and antihogbacks into the dip slope. A later stage appears on Endless Chain Ridge five and one-half miles north of Poboktan Creek. In aerial photographs a resequent stream is seen which has cut headwards into the dip sclope, and acquired radiating secondary resequents as well as a tributary subsequent (PLATE XXV). The subsequent stream has progressed nearly one-half of a mile along strike to the south. It is well on its way, in combination with obsequent streams on the escarpment face, toward significantly lowering the divide, and detaching the south extremity of Endless Chain Ridge.

The channel of Jonas Creek trends slightly oblique to the regional strike of Jonas Creek formation on which it flows. Shale lenses are present in this formation. It is probable that Jonas Creek, where migrating down-dip, took its course subject to the random distribution of these less competent beds. The creek erodes bedrock only where

it swings around the bend 3,000 feet above its mouth. Along this extent, it flows on quartzite beds through V-shaped chutes. One side of the trough is formed by twenty-degree west dip slopes and the other by fracture planes. Jonas Creek has a narrower valley than either Sunwapta River or Poboktan Creek. As a result, rock slides assume more importance in it than in the others. It is blocked by several rock slides and dammed into small lakes between two and three miles above its mouth. In its upper portion Jonas Creek has lost all contact with bedrock and meanders within muskeg flats east of Sunwapta Peak.

Poboktan and Jonas Creeks can be forded throughout most of their lengths even during high water. The danger in fording on foot is from pressure due to high current velocities, rather than from depth of water in stream channels. Sunwapta River was forded on foot near the mouth of Jonas Creek in early June, 1951. However, as spring advanced into summer glacier-melt waters were added to the river and attempted crossings ranged from dangerous to impossible. Sunwapta River was crossed with a companion in the morning of the 20th of August at a ford due west of Sunwapta Peak without difficulty. In the early evening on the return crossing the river was found to have risen over one foot with the day's melt water. When crossing Sunwapta River, one must contend with muddied chilling water through which it is impossible to watch for hollows in the stream bottor. A precaution to take in fording on foot under these circumstances it to travel with companions. All should rope together and, with the aid of sturdy staves, work one at a time across each channel anchored by the remaining companions. This method will enable the river to be crossed confidently and safely.

Tangle Ridge rises to 9,845 feet, and is the closest approach to a limestone mountain peak in the mapped area (PLATE XVIII). The summit is an easy walk by way of Tangle Creek and the south slope. Tangle Ridge is composed of beds ranging in age from Middle Cambrian to Devonian. The structure of the mountain is synclinal. The synclinal axis is continuous southward through a low trough-shaped hill to Nigel Peak (PLATE XIX). Faulting in the southwest part has had no control on the shape of the peak. Sunwapta Peak formation, Ordovician Formation A, and the Devonian system form shear cliffs on the southwest, northwest, and northeast sides (PLATE XXI). The edge of the north ridge can be ascended easily as far as the base of Ordovician Formation A. Upper Cambrian limestone beds cause steep local pitches on both sides of this ridge. Ordovician and Devonian beds are cut into castellated pinnacles and chimney rocks at many places. The south slope of Tangle Ridge is underlain by beds of Devonian age (PLATE XX). This surface is covered with scree in which vast numbers of fossils are distributed. Several broad valleys are gradually elongating headward on the slope, and enlarging as material is removed by slump, insliding, and stream action. Although a glacier is perched along the northeast side on the summit ridge signs of major glacial erosion are lacking on the mountain. The superficial features of Tangle Ridge resemble those of physiography derived under a semi-arid climate with accompanying torrential rainfall.

Three important chains of ridges in the area are as follows: Sunwapta Peak massif, Endless Chain and Jonas Ridges, and Poboktan Mountain (PLATE VII). The first two were studied carefully in the field. All have west-dip slopes and east-facing escarpments.

Sunwapta Peak massif comprises a central mountain mass rising to an altitude of 10,875 feet and a north ridge terminated near Jonas Creek camp ground. A wedge-

shaped ridge, separated from Sunwapta Peak by the north fork of Beauty Creek, is the south extension of the massif. Structure and stratigraphic sections correspond in both localities. The extension is bordered on the southwest and southeast by the south fork of Beauty Creek and its tributaries (PLATE VIII). Subsequent streams aligned with the bottom of the northeast face are carving channels near a Mount Whyte formation outcrop trend. A glacier poised below the crest of the escarpment is undermining the caprock. The dip slope is surfaced with dolomite slabs and has a relatively smooth surface. Sunwapta Peak is surfaced with Middle Cambrian shale, argillaceous limestone, and dolomite beds. Its dip slope is deeply dissected by channels of resequent streams. West of the summit the principal erosion scar is enlarged by rock slides and wash. It is floored with talus blocks ranging up to twenty feet across. The northern continuation of Sunwapta Peak is divided by a saddle in its crest line. On the east side of the continuation is a steep escarpment above Jonas Creek. The lower half of the dip slope of the west side is mantled with scree and rock slides. It is open, and its surface is even above this belt of accumulation.

Jonas Creek formation quartzites underlie Endless Chain Ridge for more than ten continuous miles along strike. These rocks are effective dip-slope material. Resequent streams with barbed and dendritic patterns at their upper extremities are present on the west side of the ridge. These characteristically maintain straight parallel courses and do not link together (PLATE XXV). The high density of these streams on Endless Chain Ridge is the most striking visible difference between its surface features and those of Sunwapta Peak. Planation usually is found to occur when channels cut through beds of varying hardnesses. Downcutting has predominated over lateral planation on the massive quartzite slopes so that established channels are incised. The escarpment face on the east side of Endless Chain Ridge slopes toward Poligne Creek. Its profile is interrupted by pitches and benches. Obsequent gullies and a few cirque-shaped funnels are present.

The quartzite beds of Endless Chain Ridge are directed into Jonas Ridge (PLATE IX). The latter continues southeastward between Poboktan and Jonas Creeks. It is terminated near Jonas Shoulder. Seen from the east Jonas Ridge presents a sharp sky-line fringed with aretes due to a development of buttresses and recesses (PLATE XII). On Jonas Ridge are seen unique examples of antihogbacks or delta-shaped point-downward suspended slabs. Some overhang Jones Creek valley with thicknesses of more than seventy-five feet. Southward on the same side of the ridge, where erosion has cut close to shaly strata, an increasing tendency for resequent channels to become dendritic headwards is noticeable in aerial photographs.

Sunwapta River rises as melt water from Dome and Athabasca Glaciers (PLATE X). These are off-shoots of the Columbia Icefield, an area of about one hundred and fifty square miles. A second major area of glaciers occurs to the northeast in Le Grand Brazeau (PLATE III). In the Rocky Mountains glacier controls in order of importance are shade, altitude, and precipitation. Aerial photographs are a useful tool for the study of glacial geology, and show that less than five per cent of the mapped area is covered with ice. Isolated glaciers are present on north and east sides of the higher peaks and ridges.

A "compound amphitheater" at the head of a tributary, which joins Poboktan Creek one mile below Waterfall Cabin, has characteristics suggestive of a glacial origin. A rock glacier at the mouth of an unrelated channel south of it is relatively recent (PLATE XXIII). This depositional feature is post-date in origin to significant glacial activity in the "amphitheater" whose exit it nearly blocks.

Hanging valleys on both sides of Sunwapta River simulate those of glacial origin. They are best developed on the west above the river in the mountains north of Diadem Peak where their contained-stream profiles coincide with transitions from subsequent to resequent channels and occur at varying levels (PLATE XI). This is satisfactory evidence that they are not glacial in origin. A creek which flows along the north side of Sunwapta Peak has a sharp break in its profile where it emerges from a valley onto the dip slope. This change takes place close to timberline. A genetic relationship with bedrock conditions may exist. The cause of the break is uncertain although this hanging valley looks like a text-book example of the glacial type. A detailed discussion of hanging valleys in the Rocky Mountains is given by J. A. Alan in his report on Field map-area[1] (pp. 40-43).

Sections drawn across Sunwapta River valley show smooth, slightly concave walls (fig. 1). A solitary valley profile is present. Signs of superimposition of a recent V-shaped alluvial valley into a glacial U-shaped one is lacking.

Geomorphic cycles will be considered next because the foregoing discussion, obviously, has been leading up to them. Three principal cycles are operative in the central Rocky Mountains—fluvial, glacial, and colluvial. The first two have been touched on under previously discussed topics. However, a few observations made upon them remain to be mentioned.

A unique situation is present in this region. The effect of falling rain is eliminated during the winter. Creeks are intermittent and dry up after freeze up. Precipitation is retained as snow and stored for seven months each year. It is released as run-off by the spring thaw. The most rapid run-off is on the southwest sides of hills, ridges, and mountains where the sun is more effective. It is delayed on the protected and shaded sides. Alluvial fans due to heavy run-off are distributed at the mouths of streams flowing into Sunwapta River from the west (PLATE XI). Results similar to those generally ascribed to desert sheet-flood flow were observed in the saddle at the southeast end of Tangle Ridge during a warm day. Excellent thaw conditions were available, and flowage of water-soaked disintegrated limestone took place with production of soil stripes. The present conclusion is that major physiographic features of the area are due to a unique type of fluvial cycle.

The region has undergone at least one earlier (Tertiary) cycle of erosion and may have inherited, in part, an apparent concordance or subequality of summits — called gipfelflur by the Germans[12] (pp. 99-101)—from it. Peneplain remnants and superimposed stream channels are absent[16] (p. 15). Limestone mountains are higher than quartzite mountains in the mapped area. This could be the result of differences in the rates of degradation of the two rock types. Normally quartzite is less susceptible to solvent action than limestone. The reason for the inversion is not clearly understood. It is possible that quartzite might break down more rapidly than limestone due to extreme temperature changes (PLATE XII).

Minor features of the erosion cycle due to rock strengths include potholes, natural bridges, and waterfalls. A few potholes in limestone beds were observed along stream channels. B. R. MacKay[16] (p. 12) has emphasized their role in the development of gorges. A natural bridge of Middle Cambrian limestone on the north fork of Beauty Creek appears to have originated from a pothole by undercut. Stanley, Symphony, and Winding Staircase falls are located along the channel of Beauty Creek. None of these are cap-rock falls.

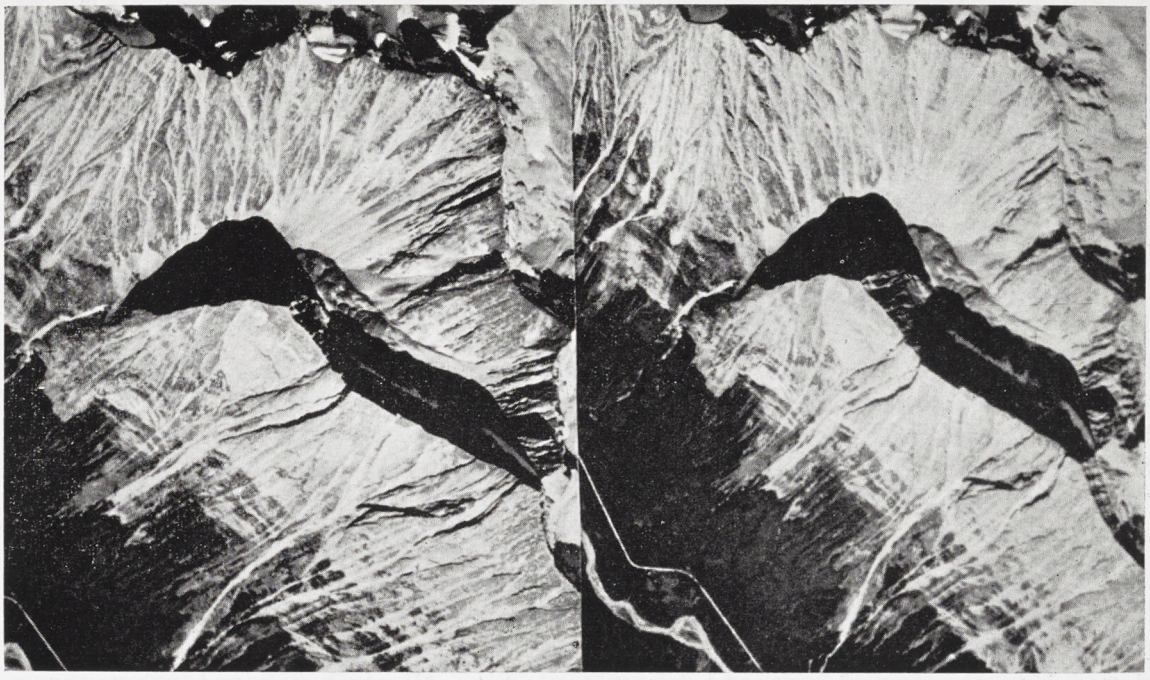


PLATE XXV.

Endless Chain Ridge about three miles north of the mouth of Poboktan Creek. The top of this pair is north.

The glacial cycle is well described by various authors[24, 12 (pp. 440-506)]. Important problems related to it in the mapped area are: the depth to which Pleistocene ice sheets buried the mountains; whether the role of glaciers was protective or erosive; and post Tertiary erosional history.

A careful watch was kept in the field for glacial polish and striae, roches moutonnees, and erratics. None was found. Relict moraines are absent. The fretted uplands of Le Grand Brazeau and aretes along the crest of Jonas Ridge are evidence of Alpine glaciation. A hypothesis of Alpine glaciers without valley glacier development fits the known facts for the area under discussion. The summits of the mountains may have been glaciated, but the bases were not.

The colluvial cycle is concerned with weathering and mass translocation of rock waste. Its effects are often wrongly accredited to the glacial cycle. Talus deposits and rock slides are present throughout most of the area. A rockslide crosses Banff-Jasper Highway at Mile 47.5. At this locality quartzite beds of Jonas Creek formation broke away from Jonas Ridge and slid westward with enough momentum to carry them across Sunwapta River. Derivative scars on Jonas Ridge indicate that the slide belt was fully one mile across. The slide tapers to one-half mile wide where it reaches the river. As Sunwapta River passes over the north edge of the slide it drops in a series of short rapids. A few of the larger talus blocks, which range up to ten feet across, protrude above the surface of the river. The slide has a fresh appearance although Coleman reported it in 1893[6].

Talus cones are found at the base of escarpments and along the sides of hogbacks (PLATE XIII). They are distinguished from alluvial cones, which have a quite different

origin (PLATE XI). Talus is characteristic of the lower dip slopes in the area. The dip slope of the north extension of Sunwapta Peak was so deeply covered with it that bedrock was obscured. Talus girdles are formed by the accumulation of rock fragments along strike on dip slopes. These superficially resemble lateral moraines. One occurs on the west side of Sunwapta Peak. It reaches from 5,950 feet at the base to 6,450 feet at the top, and trends northwestward. This girdle has been breached by a younger creek. A similar belt was found on limestone dip slopes between Poboktan Mountain and Poligne Creek.

CLIMATE

Sunwapta River area has an average annual precipitation of about seventeen inches. This occurs as winter snow, spring and summer rainfall, and autumn snow and rain. Spring is a brief season in high mountain country. Patches of snow left from the previous winter were still present at Jonas Creek campground on the 30th of May, 1951. These soon disappeared with the rapid transition from winter to summer during the first week of June.

Showers and rain fell for seven days during June, seven during July, and nine during August. Widespread snowfalls occurred on the 4th and 26th of June, the 27th of August (PLATE XIV), and the first of September. Frosts were recorded on the last day of May, the first of June, and the tenth of July. Nineteen fifty-one was neither a "wet" nor a "dry" year in this region according to inhabitants.

Weather during the field season was very agreeable. High winds, anticipated in the region and reported in the higher foot-hill mountains†, and in the Rocky Mountains,[1] (p. 50) were not encountered. Fieldwork in the mountains away from the Banff-Jasper Highway should be restricted to June, July, and August according to 1951 weather experience.

Weather data are recorded at stations in Jasper and Banff, Alberta. This information can be obtained on request from the Meteorological Service of Canada, Ottawa, Ontario.

FLORA AND FAUNA

Forest line is the upper limit of continuous forest growth, and tree line marks the upper limit of scattered trees. Forest line has grown so high on mountain slopes in the area that it corresponds with the tree line. The twain are grouped and referred to as timberline for convenience. Timberline is sinuous and ranges up to more than 6,500 feet in altitude (PLATE XXI). Spruce, balsam, and lodgepole pine are the most common forest trees. Local aspen groves occur. Labrador tea grows in the valleys at low altitude. Alpine and forest flowers of the area include red and yellow columbines, harebells, forget-me-nots, white and red heather, and Indian paintbrush.

Observed during the summer were mallard ducks, snipe, grouse, ptarmigan, hawks, bald eagles, Canada jays (whiskey-packs), ravens, slate-colored juncoes, water ouzels, chickadees, robins, and bluebirds.

Mountain goat, bighorn sheep, caribou, and moose were seen frequently in areas remote from the highway during field work. Black bear and mule deer visited the

† Statements with reference to Moon Creek Map-area by Dr. E. J. W. Irish of the Geological Survey of Canada.

base camp. Grizzly bear were not encountered, although their tracks appear in upper Poboktan Creek valley. Small game of the area includes coyotes, marmots, pikas, ground and red squirrels, and chipmunks.

ECONOMIC GEOLOGY

Metallic mineralization is uncommon in the mapped area. A few rare pyrite crystals occur in a vuggy dolomite on Beauty Creek. The dolomitic gangue rock is stained locally with black sulfide spots. It is thought that the pyrite represents reduction of iron oxides by circulating waters. Economic significance is not attached to this isolated occurrence.

Gravels suitable for road building are present in abundance in the bar plains of Sunwapta River. These are well sorted, and constituent pebbles have an average diameter not exceeding three inches. This deposit is of local importance only, and does not represent a valuable source of road gravels for areas not adjacent to Sunwapta River.

The hard quartzites of Jonas Creek formation are excellent building stones. Blocks from the rock slide at Mile 47.5 were used as trimmed decorative stone in the Information Building at Jasper, Alberta. The selected stones are attractively variegated with pink and canary yellow tones.

The most important geologic resource of the Sunwapta area and of the Rocky Mountain region is scenery, with its strong appeal to the tourist, the nature lover, the mountaineer, and to the geologist.

Three geological projects could be initiated by responsible Canadian geological societies which would render the scenery more valuable to visitors in the Park. The first project would be to follow the example set by Ardmore Geological Society, Oklahoma, whose members have erected geologic-descriptive signs along Highway 77 across the Arbuckle Mountains. Similar signs should be placed along the Banff-Jasper Highway either giving the names of formations cropping out by the road, or illustrating with cross-sections rock sequences and structures in the mountain vistas visible from the highway, or pointing out fossil localities from which tourists can gather souvenir specimens. The possible loss of choice fossil specimens, which otherwise might never have been collected, would be offset by the pleasure and interest that would be created in the amateur collector.

The second "project" that Canadian geological societies should undertake is to direct the attention of concerned government bureaus to the need for work in the Rocky Mountain region. Field mapping, rather than the measurement of stratigraphic sections, should be the ultimate aim of government geological investigation.

The third suggested project is the preparation of a loose-leaf geologic guide book for distribution to park visitors. Contents would include geologic road logs from Kananaskis to Banff, westward to Field, northward to Jasper, and thence eastward to Entrance. Extra leaves with detailed descriptions of geologic sections, fossils and local geologic features could be prepared later as additional material for publication becomes available. The Canadian Rocky Mountains is a region in which geologic information is not of a confidential economic nature. Petroleum geologists of Calgary and Edmonton would find week-end geologic fieldwork in the mountains an opportunity to lose "tight-information restraints"—so common in the oil business, to exercise their geologic judgment on worthy problems, and to bear their share of responsibility in mapping an area of great geologic importance.

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THE DEVONIAN OF JASPER PARK

A. M. PATTERSON *

The papers presented at this meeting discuss in the main the formations lying above the Devonian. This paper is included in the Guide Book merely to introduce geologists unfamiliar with the area to the Upper Devonian formations which form much of the spectacular topography of Jasper Park.

The Devonian sections in the Jasper area are among the best and most accessible in the Canadian Rockies. In most cases the structure is fairly easy to resolve and the stratigraphic sequence reasonably straightforward.

Geological work on the Devonian in Jasper Park dates back to 1859 when Dr. Hector of the Palliser Expedition made a winter trip through the Athabaska Valley. Subsequent workers were James McEvoy (1901), B. R. MacKay (1929), W. A. Kelly (1929), E. M. Kindle (1929), P. E. Raymond (1930), L. W. Collet and E. Parejas (1932), Allan, Warren, and Rutherford (1932), A. H. Lang (1947), de Wit and McLaren (1950), J. L. Sevorsen (1950), F. G. Fox (1951), Harker, Hutchinson, and McLaren (1954), and D. J. McLaren (1954). (See Figure 2.)

Despite the amount of work done so far many questions and contradictions still remain. Some of these are outlined at the end of this paper.

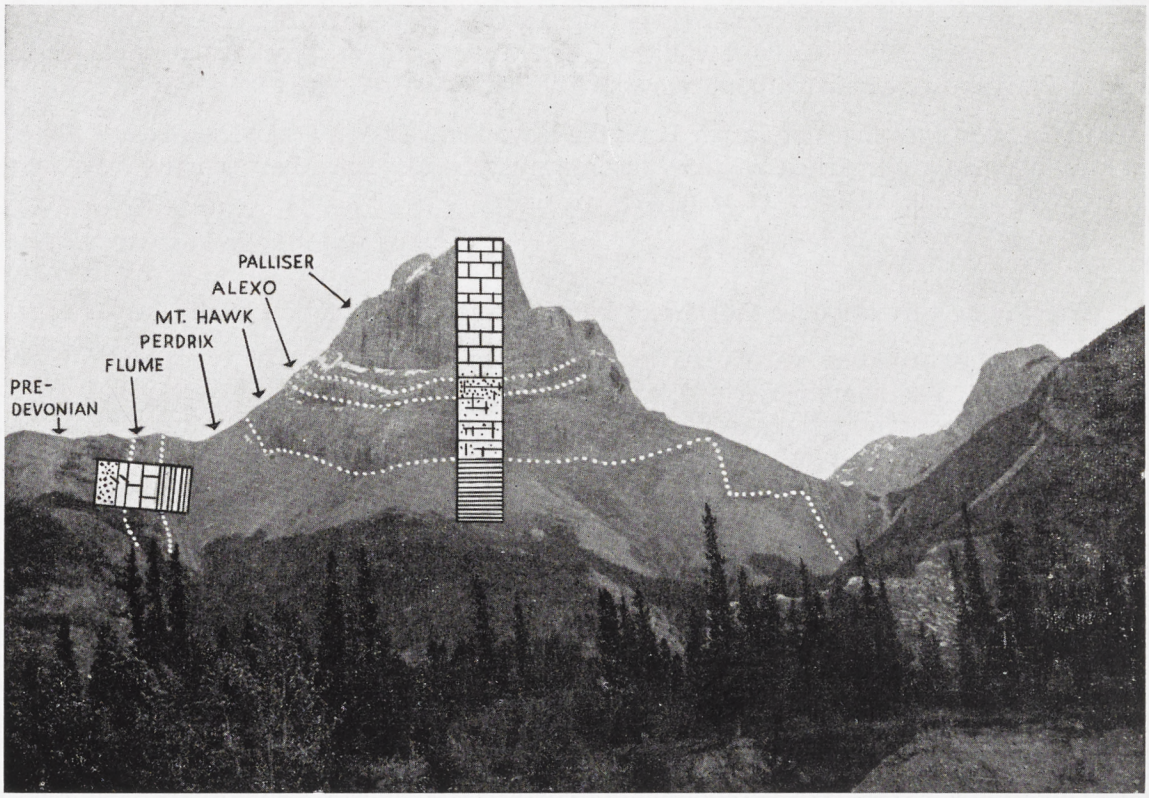


PLATE I

Roche Miette with lithology and formation boundaries superimposed.

* Geologist, Merrill Petroleums. The field work in connection with this paper was sponsored by Merrill Petroleums Limited to whom the writer tenders grateful acknowledgment.

About 2300 feet of Devonian section are found in the Jasper Area. The Devonian is underlain by either Ordovician or beds of undetermined age and is overlain by Mississippian rocks. The Devonian sequence starts with the Flume formation of Middle and Upper Devonian age. The Flume is a carbonate formation often showing reefal tendencies. The Flume is overlain by the Perdix formation composed of black limy shale. Overlying the Perdrix are calcareous shales and argillaceous limestones of the Mount Hawk formation. Overlying the Mount Hawk is the Alexo formation composed of siltstone and silty limestone. Overlying the Alexo are the massive fine grained limestones of the Palliser, the uppermost of the Devonian formations in the Jasper area. Roche Miette may be considered as being more or less the type section for all these formations in the Jasper area (see PLATE I).

At the north and south ends of Jasper Park the Fairholme reef facies replaces the Perdrix and Mount Hawk formations.

THE SUB DEVONIAN UNCONFORMITY

In the eastern ranges of Jasper Park south of the Athabaska River the Flume and Fairholme formations rest on beds of undetermined age. These beds, dolomites, silty dolomites, and siltstones, are similar lithologically to the Ghost River formation. Neither these beds nor the Ghost River beds to the south have yielded diagnostic fossils and their age is unknown. Webb (1954, p. 10) and Andrichuck (1954, p. 75), suggest that the Ghost River may be Middle Devonian and may correlate with the Elk Point formation. The writer has heard numerous geologists wax eloquent on Silurian or Ordovician age for the Ghost River. At present the Ghost River and its possible correlatives in Jasper Park must remain without age connotation.

In the western ranges of Jasper Park the Devonian rests on Ordovician beds. At no one locality can any marked angular unconformity be discerned between the Devonian and the Ordovician (Harker et al p. 62).

FLUME FORMATION

The Flume formation is the lowest known Devonian formation in the Jasper area.

The Flume formation was named by P. E. Raymond in 1930. The type section is on Roche Miette. The name is derived from a small creek near the type section. Due to Raymond's misconceptions regarding the structure of his type section the name was practically meaningless until 1947 when it was used by Lang (1947, pp. 13-16).

The Flume consists of a lower member of limestone and dolomite, dark grey and dark brown to light grey, ranging from coarsely to finely crystalline to sugary. This unit is commonly fairly thickly bedded and competent. It frequently becomes reefal and in almost all localities contains a large percentage of algal and stromatoporoidal material.

The upper member consists of limestone, dark grey, fine to medium crystalline, argillaceous, and fossiliferous. Black shale breaks become more common upward (see PLATE II). One widespread zone of black chert nodules occurs near the top.

The Flume varies considerably in thickness. The thicker sections are commonly the more reefal sections and these are usually located close to Fairholme reefs.

Thicknesses of some of the Jasper sections are given below:

Palisade ----------250 feet

Cold Sulphur Springs	150 feet
Roche Miette	280 feet
Roche a Perdrix	150 feet (minimum)
Mt. McKenzie	469 feet (reefal)

Excellent and accessible sections of Flume may be seen at Cold Sulphur Springs and Roche a Perdrix. Good, but less accessible sections are found on the Palisade and on Roche Miette.

PALEONTOLOGY AND CORRELATION

Most of the fossils collected from the Flume are from the upper member. While the lower member is frequently composed almost entirely of organic debris the state of preservation usually is too poor to permit identification.

The collections of the upper member contain the typical *"Spirifer jasperensis"* fauna of Warren (Allan, Warren, and Rutherford (1932, pp. 233-238):

Pugnoides kakwaensis

Atrypa cf. *albertensis* Warren

Atrypa cf. *devoniana* Webster

Nudirostra athabascensis Kindle

Eleutherokomma hamiltoni Crickmay

Eleutherokomma leducensis Crickmay

This assemblage has both Middle and Upper Devonian affinities. Correlation with the Beaverhill Lake formation is strongly suggested. It is possible that the Flume formation may actually include some beds higher than the top of the type section of the Beaverhill.

PERDRIX FORMATION

The Perdrix formation was named by P. E. Raymond in 1930. The type section is on Roche Miette. The name is derived from Roche a Perdrix some eight miles east of the type section.

The Perdrix overlies the Flume formation and underlies the Mount Hawk formation. Both the upper and lower contacts of the Perdrix are conformable and gradational. The Perdrix consists of black, limy, silty shale that commonly weathers a tan-brown color. Limestone bands are rare in the Perdrix except towards the base where a few fossiliferous Flume-type limestone bands occur. As Fairholme reefs are approached the basal Perdrix becomes increasingly limy. In the southern part of Jasper Park the shales become grey and south of the Park a greenish cast is evident particularly in the upper part. The thickness of the Perdrix varies from about 300 feet to 600 feet, the greater thickness being more common.

Thicknesses of some of the Jasper sections are given below:

Palisade	390 feet
Morrow Peak	550 feet

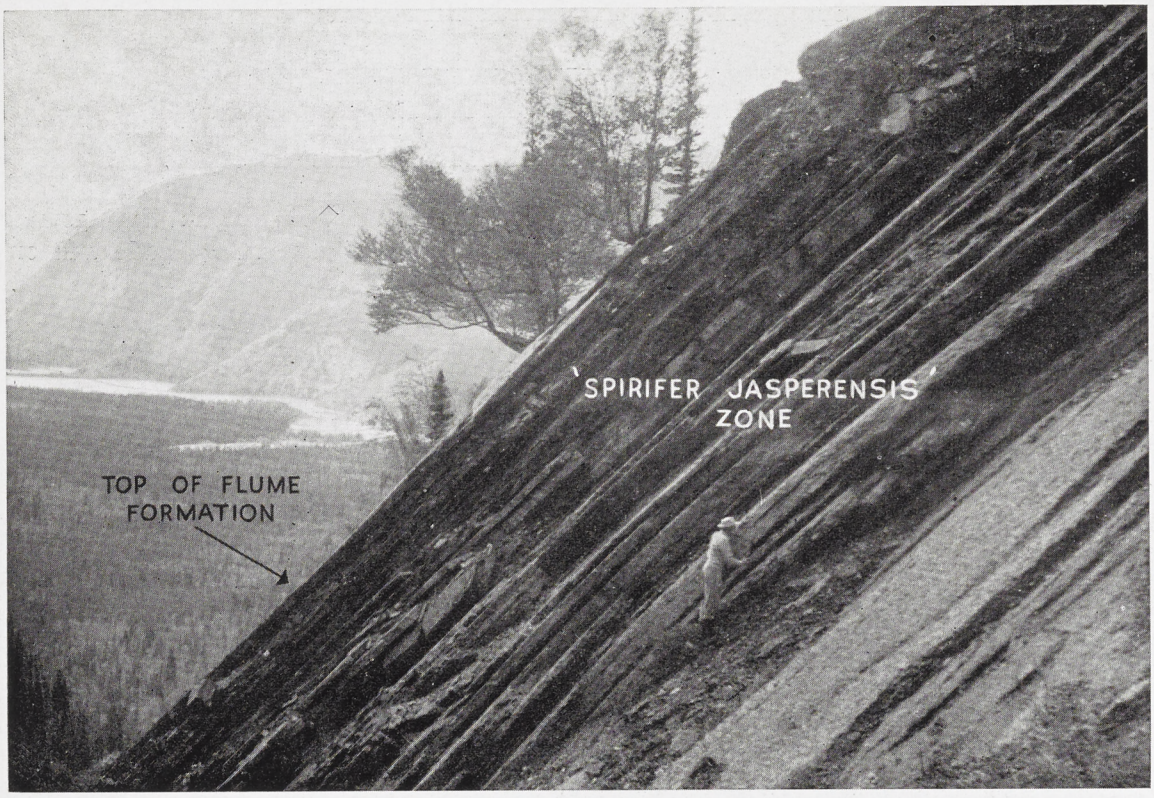


PLATE II

Upper Flume formation on Roche a Perdrix

Roche Miette	270 feet
Roche a Perdrix	440 feet

PALEONTOLOGY AND CORRELATION

The Perdrix formation is sparsely fossiliferous with the exception that *Tentaculites* are abundant particularly towards the base. Some sections have yielded an Ireton microfauna. The Perdrix correlates with the Duvernay and the lower part at least of the Ireton members of the Woodbend formation.

MOUNT HAWK FORMATION

The Mount Hawk formation was named by de Wit and McLaren in 1950. The type section is on Roche Miette. The name is taken from Mount Hawk some 10 miles west of the type section.

The Mount Hawk formation overlies the Perdrix and underlies the Alexo. The lower contact is conformable and gradational. The upper contact varies from abrupt and exhibiting a marked faunal change to gradational and practically indistinguishable.

The Mount Hawk consists of from 200 to 490 feet of thin bedded argillaceous and silty, fossiliferous limestones interbedded rhythmically with shale partings. The contact with the Perdrix formation is marked by the predominance of black shale. The upper contact in the Jasper area is usually marked by abrupt increase in silt as the Alexo

formation is reached. The Mount Hawk is mildly cliff forming (in marked contrast to the incompetent Perdrix). Fairly numerous reef growths occur in the Mount Hawk. These reefs are easily recognized in outcrops as their massive, structureless character contrasts with the regular bedding usually found in the Mount Hawk. A good example of these reefs may be seen on the east face of Cinquefoil Mountain, when viewed from the vicinity of Edna Lake (See PLATE III).

Some thicknesses of the Mount Hawk in the Jasper area are given below:

Palisade	300 feet
Morro Peak	450 feet
Roche Miette	475 feet
Roche a Perdrix	480 feet

PALEONTOLOGY AND CORRELATION

The Mount Hawk is very fossiliferous usually with brachiopods abundant at the top and bottom of the formation and corals predominant in the middle.

The fauna includes:

Nudirostra albertensis Warren.

Productella hallana Walcott

Pugnoides calvini Fenton and Fenton

Atrypa sp. cf. *A devoniana* Webster

Cyrtospirifer cf. *whitneyi* Hall

Martiniopsis cf. *nevadensis*

The common corals include:

Alveolites cf. *suborbicularis*

Syringopora sp Lamarck

Synaptophyllum camselli Smith

Phillipsastrea vesiculosa Smith

The Mount Hawk probably correlates with the upper part of the Ireton member of the Woodbend formation and all of the Nisku member of the Winterburn formation.

The Mount Hawk is considered by Fox to be a lower member of the Cheviot formation (Fox 1951, p. 834) (see Cheviot formation).

Excellent sections of the Mount Hawk are found at Palisade, Morro Peak (Cold Sulphur Springs), Mount Greenock, Roche Miette, and Roche a Perdrix.

ALEXO FORMATION

The Alexo formation was named by de Wit and McLaren in 1950. The type section is at the Gap on the Saskatchewan River. The name is derived from the town of Alexo near the Gap.

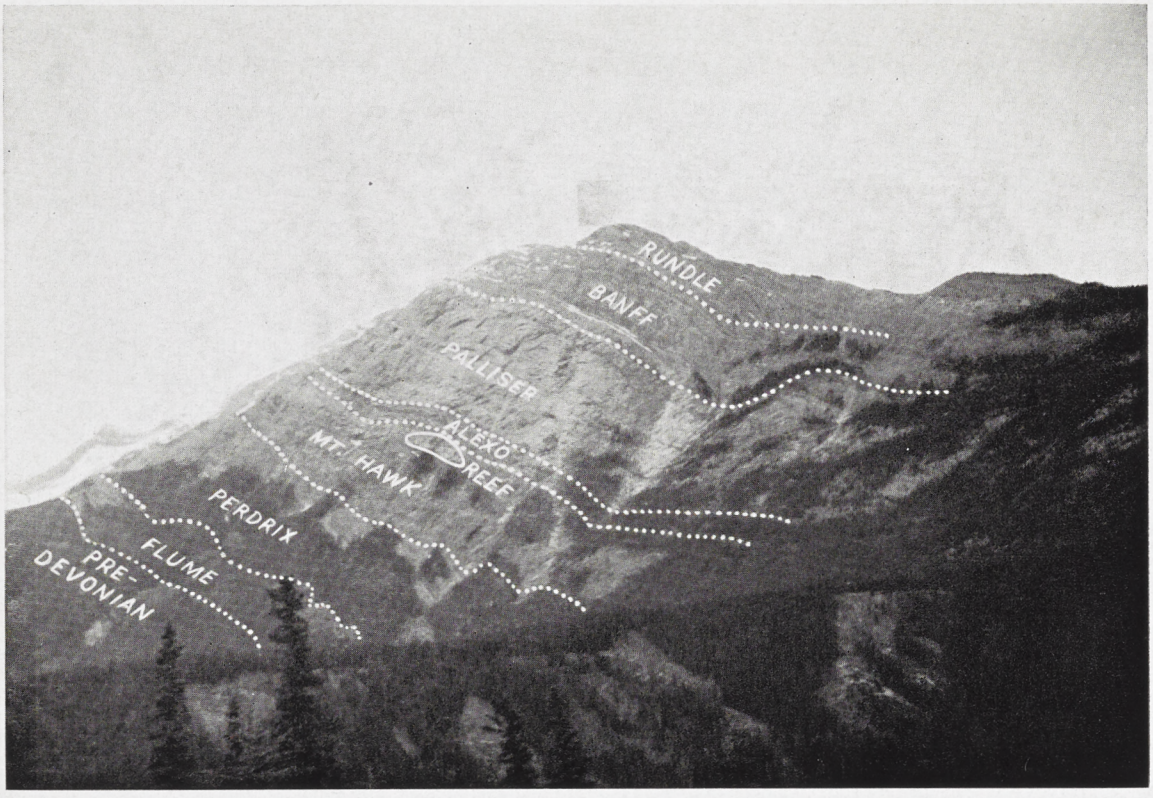


PLATE III

East face of Cinquefoil Mountain viewed from Edna Lake. Possible reef development shown in Mount Hawk formation.

The Alexo formation in the Jasper area consists of about 200 feet of laminated silty limestones and dolomites. In some localities, mudstones occur and the upper part becomes a sandstone. The contact with the underlying Mount Hawk is often gradational (see Cheviot formation) and is picked on the lack of predominant silt in the Mount Hawk.

The Alexo formation commonly weathers a rusty brown color in the Jasper area.

Thicknesses of the Alexo at some Jasper sections are given below:

Palisade	300 feet
Morro Peak	400 feet
Roche Miette	200 feet
Roche a Perdrix	130 feet

PALEONTOLOGY AND CORRELATION

Fauna typical of the Alexo are:

Pugnoides sp

Athyris cf. *angelicoides* Merriam

Nudirostra gibbosa walcotti Merriam

Camarotoechia sp

The Alexo probably correlates with the Calmar member of the Winterburn formation. The top of the Alexo may actually occur somewhere in the Graminia member.

The Alexo is considered by Fox (1951) to be an upper member of the Cheviot formation.

CHEVIOT FORMATION (Fox 1951).

The Cheviot formation embraces the Mount Hawk and Alexo formations of de Wit and McLaren. As proposed by Fox (1951) the Mount Hawk and Alexo formations would be members of the Cheviot. Fox's arguments are based on the fact that at some localities the Mount Hawk-Alexo contact cannot be picked by a geologist in the field and neither the Mount Hawk nor the Alexo constitute mappable units. There is merit in the arguments on both sides of the question. In the Jasper Park area (with the exception of the very northern part) the Alexo and Mount Hawk can be fairly easily differentiated.

FAIRHOLME FORMATION

The Fairholme formation was named by Beach in 1943. The type section is in the Banff area.

The Fairholme formation occurs at the north and south extremities of Jasper Park (see Figure 1). Sections have been reported by McLaren from the vicinity of the Brazeau River at the south and from near Winnifred Pass and the Ancient Wall at the north (D. J. McLaren 1953, p. 89).

The Fairholme is a carbonate reef and back reef facies that replaces the Flume, Perdrix, and Mount Hawk formations. It can be divided into upper and lower members. The lower member is dolomite, dark grey to dark brown, coarsely crystalline, saccharoidal, vuggy to cavernous, and fetid. Stromatoporoids, algae, and bryozoans, are typically abundant.

The upper member consists of dolomite, light grey, fine to coarsely crystalline, becoming less massive and more thinly bedded toward the top. This upper zone may represent reworked reef. In the Sunwapta Pass area the Fairholme is about 1150 feet thick. The most easily accessible sections of the Fairholme in the Jasper area are on the Banff-Jasper Highway on Nigel Peak, and Mount Coleman.

PALEONTOLOGY AND CORRELATION

The Fairholme formation replaces the Flume, Perdrix, Mount Hawk, and Alexo (?) formations. It probably represents an upward reefal growth of the Flume formation at localities where the environment favored such growth. The reef growth probably preceeded the deposition of most of the off-reef clastics so only the basal part of the Perdrix would be the time equivalent of the Fairholme.

Similarly, the Fairholme reefs, starting as they did in Beaverhill Lake time probably preceeded most of the known "Leduc" reef growths (see Figure 3). Despite this, there is an undoubted relationship between the reef occurrences in the mountains and the known reef "trends" in the plains area.

PALLISER FORMATION

The Palliser formation was named by Beach in 1943. The type section is in the Banff area.

The Palliser constitutes the uppermost formation of the Devonian sequence in the Jasper area. It consists of 750 feet to 1000 feet of massive cliff forming limestones. It is responsible for most of the spectacular topography of the eastern ranges of the Rockies south of the Peace River.

The Palliser is typically very massive, cliff-forming limestone with a dolomite tracery (agal) throughout. Silt in minor quantities sometimes occurs toward the base.

In the Jasper area the contact of the Palliser and Alexo (and/or Cheviot) is quite abrupt and is marked by the change from the large silt content and thin bedding of the Alexo to the minor silt content and massive bedding of the Palliser.

The Palliser has been divided into a lower Morro and an upper Costigan members (de Wit and McLaren 1950). The Costigan member (more rubbly and dolomitic than the Morro) is not particularly well developed in the Jasper area.

The Palliser is overlain unconformably by the Exshaw formation of disputed Devonian-Mississippian age. The Exshaw is considered by the writer to be Mississippian. The top of the Palliser represents an erosional unconformity with local relief of up to 20 feet in some localities.

Thicknesses of some Jasper sections of the Palliser are:

Palisade	1000 feet
Morro Peak	880 feet
Roche Miette	700 feet
Roche a Perdrix	910 feet

PALEONTOLOGY AND CORRELATION

The Palliser on the whole is sparsely fossiliferous with the exception of the upper few feet which, in most localities, yield an abundant fauna known as the *Cyrtospirifer whitneyi* fauna.

Athyris angelica Hall

Athyris cora Hall

Camarotoechia banffensis Warren

Camarotoechia nordeggi Kindle

Cyrtospirifer cf. *kindlei* Stainbrook

Productella cf. *lata* Warren

In some localities collections from the Palliser have shown Mississippian affinities (Fox 1951, p. 843). In general however the Palliser is considered to be Upper Devonian.

The Palliser correlates with the Wabamun formation and probably all of the Graminia member of the Winterburn formation of the Plains area.



INDEX MAP OF SOME

PUBLISHED SECTIONS OF THE UPPER DEVONIAN IN JASPER NATIONAL PARK

Scale in Miles

0 8 16 32 48 64

Areas where FAIRHOLME REEFS have been reported or may be expected.

FIGURE NO. 1

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FIGURE NO. 2

EVOLUTION OF UPPER DEVONIAN NOMENCLATURE IN JASPER AREA 1926 — 1950

PRE-DEVONIAN	MIDDLE ? DEVONIAN	UPPER DEVONIAN	
	MINNEWANKA LIMESTONE		SHIMER 1926 (Banff)
	MINNEWANKA (Lower Part)	MINNEWANKA (Upper Part)	WARREN 1927 (Banff)
	LIMESTONE DOLOMITE UNIT	CALCAREOUS SHALE and ARG. LIMESTONE UNIT / LIMESTONE UNIT	MacKAY 1929 (Jasper)
		BLACKFACE MTN. SHALE	KELLY 1929 (Jasper) Unpublished
	MINNEWANKA		KINDLE 1929 (Jasper)
		MIETTE SHALE MEMBER	
	FLUME / PERDRIX / BOULE / CORONACH / FIDDLE / KILN		RAYMOND 1930 (Jasper)
	MINNEWANKA		ALLAN, WARREN & RUTHERFORD 1932 (Jasper)
	LOWER MINNEWANKA / BLACKFACE MTN. SHALE	UPPER MINNEWANKA	
	FAIRHOLME	PALLISER	BEACH 1943 (Banff)
	FLUME	PERDRIX / BOULE	LANG 1947 (Jasper)
	FAIRHOLME: FLUME / PERDRIX / MT. HAWK / ALEXO	PALLISER	deWIT McLAREN 1950 (Jasper)
	FAIRHOLME: FLUME / PERDRIX / CHEVIOT: MT. HAWK / ALEXO	PALLISER	FOX 1950 (Jasper)

NOTE: *FIDDLE, CORONACH, and KILN are probably repetitions of FLUME, PERDRIX and BOULE.*

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CONCLUSION

Even in the recent published works on the Devonian in the Jasper area considerable disagreement is found. The writer makes no attempt to resolve these questions but outlines the more major discrepancies in order to simplify casual study of the literature and bring some of the problems to more widespread attention.

1. Lang (1947) recognized the change in lithology between what are now called Mount Hawk, Alexo, and Palliser, but included them all in his Boule formation.
2. Severson (1950) includes beds equivalent to the Alexo in the Palliser formation. At the time of Severson's publication the Alexo had not been named but this usage was contrary to that of Beach who named the Palliser and Fairholme formations. Beach definitely included the silty and sandy beds now called Alexo in the Fairholme formation.
3. de Wit and McLaren consider the Alexo formation to overlie the Fairholme. Their work constitutes a revision of the Fairholme as defined by Beach.
4. Fox does not believe that the Mount Hawk and Alexo rate formational status. He suggests they be considered as members of the Cheviot formation. Also contrary to de Wit and McLaren, Fox follows the original definition of the Fairholme as including the silty and sandy "Alexo equivalent."
5. The word Fairholme has now accrued definite facies connotations and cannot be applied to the off-reef facies (Perdrix, etc.) of the Upper Devonian. It has been suggested that a group name be given to this off-reef facies for ease of reference. The writer is not convinced of the need of such a group name.

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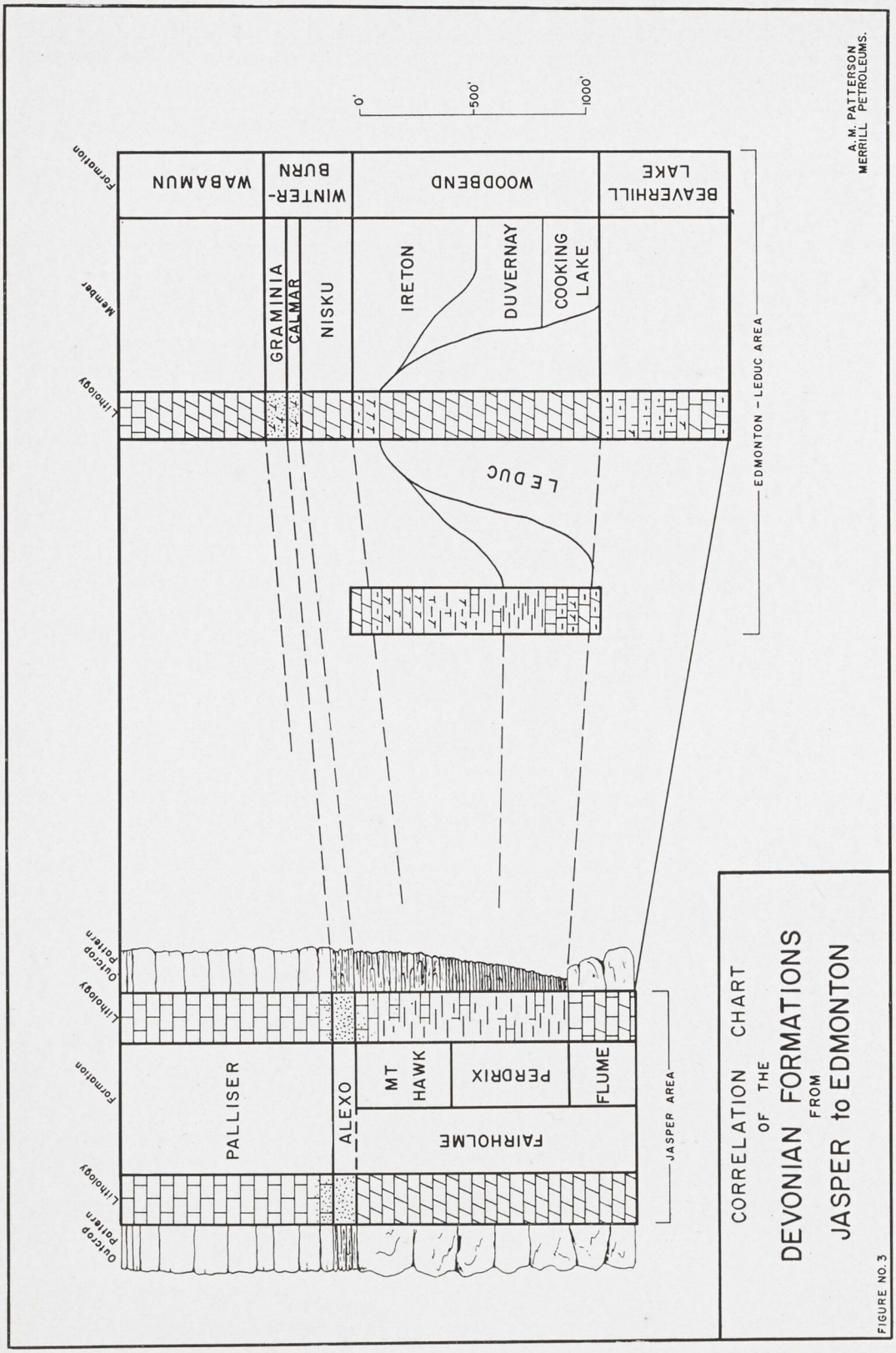

CORRELATION CHART
OF THE
DEVONIAN FORMATIONS
FROM
JASPER to EDMONTON
A. M. PATTERSON
MERRILL PETROLEUMS.
0'
500'
1000'
Formation
Member
Lithology
Outcrop Pattern
WABAMUN
WINTER-BURN
GRAMINIA
CALMAR
NISKU
WOODBEND
IRETON
DUVERNAY
COOKING LAKE
BEAVERHILL LAKE
LEDUC
EDMONTON - LEDUC AREA
PALLISER
ALEXO
FAIRHOLME
MT HAWK
PERDRIX
FLUME
JASPER AREA

FIGURE NO. 3

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NOTES TO ACCOMPANY
CROSS-SECTIONS OF FOOTHILLS BELT EAST OF JASPER PARK

By (*) C. O. HAGE and (†) J. B. WEBB

The portion of the Foothills belt lying east of Jasper Park adjacent to Highway 16 has been mapped and reported on by the Geological Survey of Canada, Brûlé and Entrance Map-Areas, Memoir 244, by A. H. Lang, 1947. Two deep test wells have been drilled in this Area. In 1944-45 Anglo Canadian Oil Company associated with Royalite Oil Company and Home Oil Company drilled their Jasper Syndicate No. 1 well at Folding Mountain to a depth of 5,096 feet. At 4,899 feet the well passed from Devonian shale back into the Blairmore formation indicating a thrust fault of considerable magnitude underlying the Folding Mountain anticline. Shell Oil Company drilled their Solomon Creek No. 1 well to a depth of 4,774 feet in 1943-44. This well was deepened in 1952-53 by New Superior Oils of Canada Ltd. and associates to a depth of 11,321 feet. Both of these wells have been abandoned.

Two cross sections have been constructed across the Foothills belt through these respective wells. Section A-A* by J. B. Webb crosses Folding Mountain and trends nearly parallel with Highway 16. Section B-B* by C. O. Hage crosses the Solomon Creek anticline through Superior et al Solomon Creek No. 1 well.

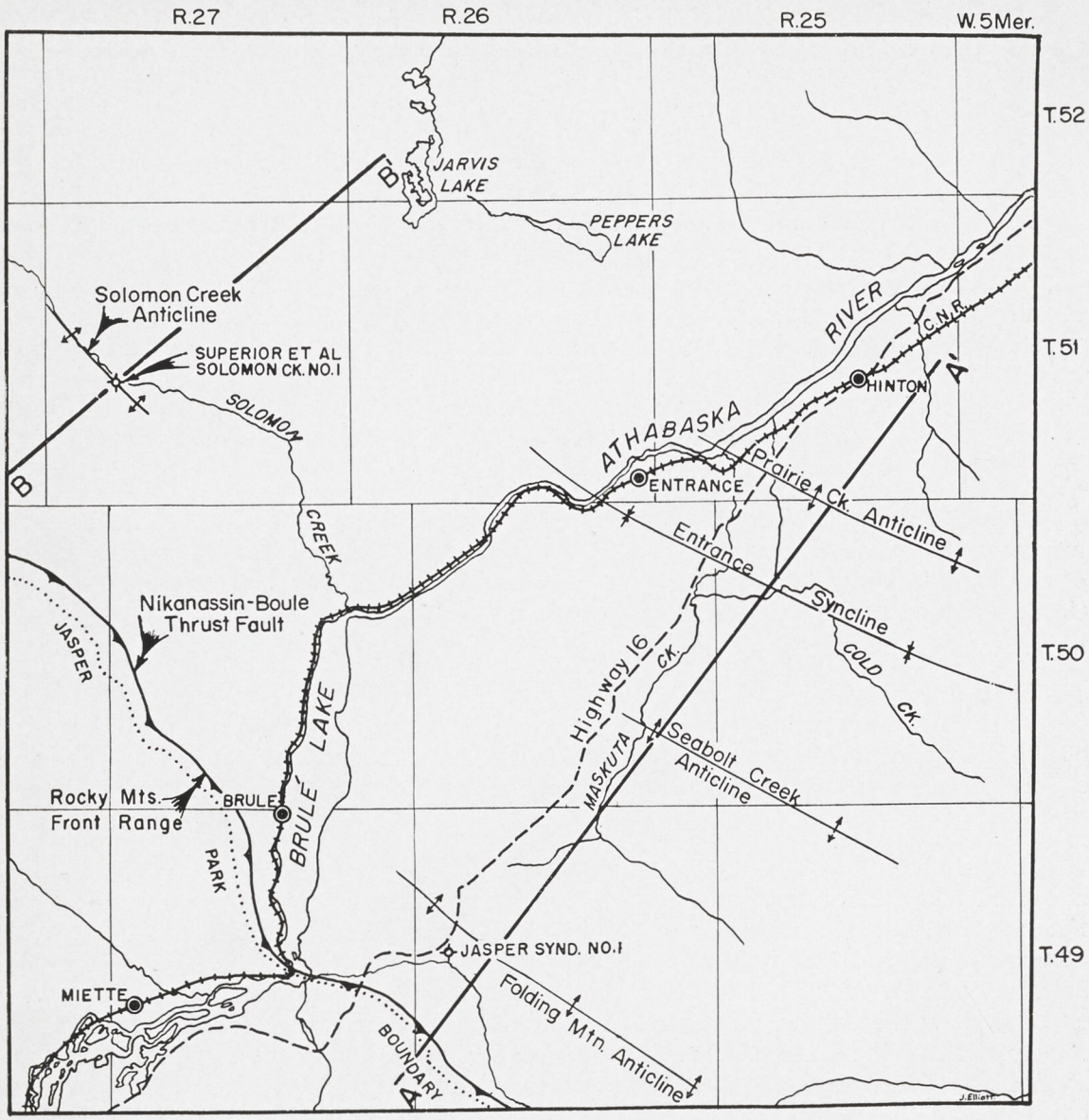
The Foothills belt along section A-A* has a width of about 15 miles whereas along section B-B* the width is about 10 miles. The decrease in width of the Foothills belt to the north, accompanied by steeper-dipping beds, suggests that the northern part of the area may have been subjected to greater compressive stresses. The presence of the large south plunging Entrance syncline south of the Athabaska River supports this idea.

Strata ranging in age from Mississippian to Tertiary (Paleocene) outcrop in this disturbed belt. Mississippian, Triassic, Jurassic and Lower Cretaceous strata occur on Folding Mountain and the remaining part of the succession is intermittently exposed at various places. Outcrops are generally scarce along the Athabaska River valley because of the thick glacial deposits. The Upper Cretaceous Brazeau formation is well exposed along the Athabaska River in the vicinity of Entrance for about five miles. This portion of the river channel is narrower and probably of post glacial origin in contrast to the wider pre-glacial channel to the west. A glacial moraine appears to have blocked the old river channel close to the outlet of Brûlé Lake. Below this point to the mouth of Maskuta Creek the location of the old channel is not definitely known. There is a possibility that it may have occupied the Maskuta Creek valley along which the Jasper Highway is located. Brûlé Lake is believed to be the remnant of a much larger glacial lake which once occupied part of the valley. The outlet from this lake may have flowed northeast through the lower part of Solomon Creek valley, north of Solomon Mountain and through a valley now occuppied by Jarvis, Blue, Graveyard and Gregg Lakes and into Wildhay River.

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INDEX MAP

SHOWING

LINES OF CROSS SECTIONS

AND

SOME MAJOR STRUCTURAL FEATURES

0 1 2 3 4 5

SCALE IN MILES

JULY 1955

CROSS SECTIONS

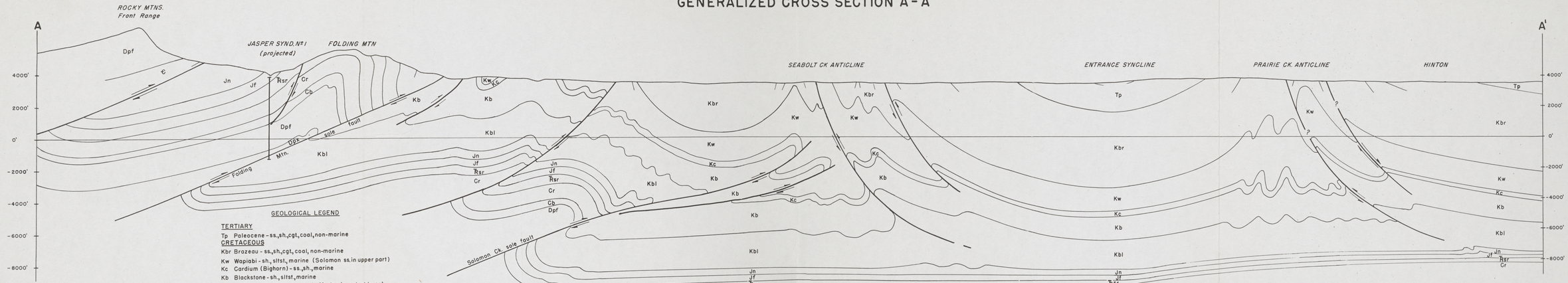
A-A' BY J. B. WEBB

B-B' BY C. O. HAGE

Fig. 1

GENERALIZED CROSS SECTION A - A'

S.W. — N.E.



GEOLOGICAL LEGEND

TERTIARY

Tp Paleocene - ss., sh., cgt., coal, non-marine

CRETACEOUS

Kbr Brazeau - ss., sh., cgt., coal, non-marine

Kw Wapiabi - sh., siltst., marine (Solomon ss. in upper part)

Kc Cardium (Bighorn) - ss., sh., marine

Kb Blackstone - sh., siltst., marine

Kbl Blairmore - ss., sh., cgt., coal (Cadomin cgt. at base)

JURASSIC

Jn Nikanassin - ss., sh., mainly non-marine (upper part may be of Lower Cretaceous age)

Jf Fernie - sh., ss., ls., marine (Nordegg member at base)

TRIASSIC

Rsr Spray River - sh., siltst., ss., marine (Whitehorse member - ls. in upper part)

MISSISSIPPIAN

Cr Rundle - ls., dol., sh., marine

Cb Banff - calc. sh., ls., marine

DEVONIAN

Dpf Palliser - Fairholme (undivided) ls., dol., marine

Dpx Perdrix - sh., blk., & argil. ls.

CAMBRIAN

Є siltst. & dol. (may be equivalent to Ghost River)

0 1 2

VERTICAL & HORIZONTAL SCALE IN MILES

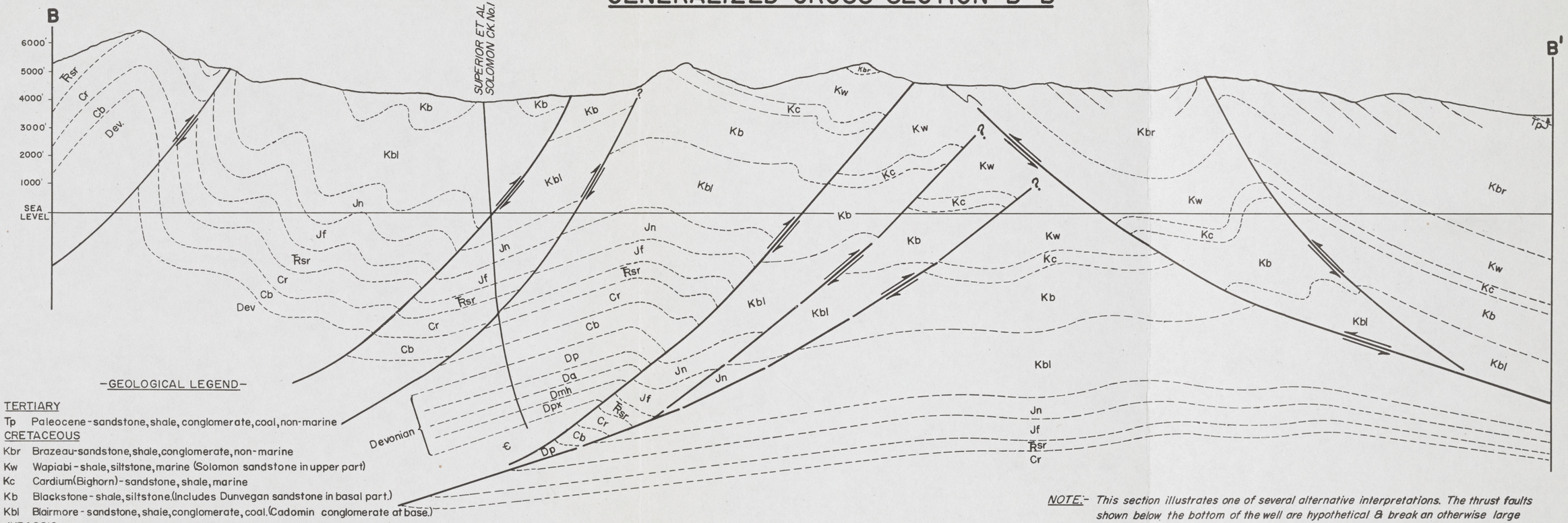
NOTE:- This section illustrates one of several possible alternative interpretations. Folding Mountain sole fault probably crops out as indicated but, due to lack of exposure, cannot be observed. The hypothetical Solomon sole fault may have no surface expression other than a severely fore shortened zone in the Cretaceous beds. Two surface features, Seabolt Creek and Prairie Creek anticlines, are broken by east dipping faults. These uplifts may be superficial, due to fore shortening of the Cretaceous beds, the underlying, competent Palaeozoic strata remaining undisturbed.

SOURCE OF INFORMATION:-

Surface geology from Geol. Surv. of Canada, Entrance Sheet, by A.H. Lang & field work by J.B. Webb for Anglo-Canadian Oil Co. Ltd. Log of Jasper Syndicate No 1 supplied by Anglo-Canadian Oil Co. Ltd.

J.B. WEBB-JULY 1955

GENERALIZED CROSS SECTION B-B'



-GEOLOGICAL LEGEND-

TERTIARY

Tp Paleocene - sandstone, shale, conglomerate, coal, non-marine

CRETACEOUS

Kbr Brazeau-sandstone, shale, conglomerate, non-marine

Kw Wapiabi - shale, siltstone, marine (Solomon sandstone in upper part)

Kc Cardium (Bighorn) - sandstone, shale, marine

Kb Blackstone - shale, siltstone. (Includes Dunvegan sandstone in basal part.)

Kbl Blairmore - sandstone, shale, conglomerate, coal. (Cadomin conglomerate at base.)

JURASSIC

Jn Nikanassin - sandstone, shale, mainly non-marine. (maybe in part Cretaceous.)

Jf Fernie - shale, sandstone, limestone, marine

TRIASSIC

Rsr Spray River - siltstone, sandstone, marine (Whitehorse Member - limestone & dolomite in upper part.)

MISSISSIPPIAN

Cr Rundle - limestone, dolomite, shale, marine

Cb Banff - calcareous shale, limestone, marine

DEVONIAN

Dp Palliser - limestone & argillaceous limestone

Da Alexo - limestone, siltstone, shale

Dmh Mount Hawk - limestone, shale, minor siltstone

Dpx Perdrix - shale black, some limestone

CAMBRIAN

€ siltstone & dolomite (maybe equivalent to Ghost River)

0 1 2

VERTICAL & HORIZONTAL SCALE IN MILES

NOTE:- This section illustrates one of several alternative interpretations. The thrust faults shown below the bottom of the well are hypothetical & break an otherwise large east dipping anticlinal flank.

The east dipping thrust faults are believed to be later than the west dipping thrust faults.

SOURCE OF INFORMATION:-

Surface geology from Geol. Surv. of Canada - Brulé sheet by A.H. Lang & field work by C.O. Hage. Log of Superior et al Solomon Creek No. 1 supplied by New Superior Oils of Canada Ltd.

C.O. HAGE — July 1955

POCAHONTAS - MOOSEHORN CREEK COAL BASIN JASPER PARK, ALBERTA

B. R. MacKAY*

INTRODUCTION

This paper has been prepared at the request of the editor of the Guide Book, in response to his plea that a goodly number of our members are probable not aware that Pocahontas is the site of what was, forty years ago, a flourishing colliery. To most, the name is generally associated with the Park Warden's Station, Punchbowl Falls, or the gateway to the 12-mile scenic motor road that leads up Mountain Creek, Fiddle River and Sulphur Creek to the famed Miette Hot Springs.

The name "Pocahontas" was given in 1911 to the Grand Trunk Railway station and the Post Office at the request of the American Directors of Jasper Park Collieries Ltd. It was named after the mining town, Pocahontas, located in the centre of the well known low-volatile bituminous coalfield of southwestern Virginia, that was founded in 1882 and famed abroad for its exhibition coal mine. At that time, the Directors were hopeful that the coal of their newly discovered field would prove comparable in quality and use to that of the renowned American field. Unfortunately, due to a combination of factors, this did not prove to be the case. The colliery, for which a glowing future was envisioned in 1911, continued in operation for a period of only 10 years with an aggregate production of 840,200 tons of coal and was then closed down. The salient features of early exploration through Kickinghorse Pass, the discovery of coal, a brief history of operations of the colliery, and the reason for closing the mine can be briefly sketched.

Ever since early fur-trading days, the Athabasca Valley has been one of the main routes of travel through the Rocky Mountains. It was traversed by such explorers as David Thompson in 1814[18], Ross Cox in 1817, Father De Smet in 1846, Gabriel Franchère in 1854[5], James Hector in 1859[7], Viscount Milton and Dr. W. B. Cheadle in 1863[16], Sir Sanford Fleming and Rev. G. M. Grant in 1872[6], and by James McEvoy in 1898. McEvoy's report[15] contains references to the pertinent observations of most of these earlier explorers. No mention is made in the reports of the presence of coal at or near Pocahontas. As far back as 1846, the Athabasca valley in the vicinity of Roche Miette and Roche Ronde was painted by the noted artist Paul Kane, but at the time he was more concerned with the majesty of these mountains and the intense force of the wind that howled through the Pass than with the existence of coal.

It remained for an energetic prospector, Frank Villeneuve, and a companion, Alfred Lamoreau, while engaged in a scouting expedition in 1908, a little in advance of the construction of the Grand Trunk Pacific Railway through the Yellowhead Pass, to discover 'coal-float' on the lower northeastern slope of Roche Miette (PLATE 1), and to follow up this find with the discovery of coal seams of minable thicknesses at the eastern base of Miette Mountain, and later on the north bank of the Athabasca River and up Moosehorn Creek. Accordingly, on October 3rd, 1908, two coal claims, each 1 mile wide and 4 miles long, were staked out from an initial post located on the north bank of Athabasca River at the mouth of Moosehorn Creek. One of these, in the name of

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PLATE 1.

View from high gravel terrace on east side of Mountain Creek at Pocahontas looking south across coalfield to Roche Miette, elevation 7377′, showing in foreground the cavings along the outcrop of the mined-out Tunnel seam.

Frank Villeneuve, extended for 4 miles southeastwards across Athabasca River and up the valley of Mountain Creek, and the other, in the name of Alfred Lamoreau, extended northwestwards up the valley of Moosehorn Creek (PLATE 2).

Shortly after the staking of the claim, Villeneuve succeeded in interesting Canadian and American financiers in the coal discovery and leases, which resulted in the formation of Jasper Park Collieries, and a program of intensive prospecting that increased their holdings to 8 mining leases with an aggregate coverage of 28.75 square miles. When the claims were filed, the territory had not been subdivided. This, however, was immediately done, and the leases were adjusted to conform with the legal land subdivisions. The area underlying the flats of Athabasca River was excluded from the leases, with the result that the lease area covering the desired coal measures was reduced to 5 mining leases with a coverage of 12.45 square miles (see claims map—Fig. 1).

Intensive prospecting was then undertaken, the greatest activity being directed to the south side of the Athabasca River, where every effort was made to be ready to ship coal as soon as the Grand Trunk Pacific Railway reached the colliery and could be

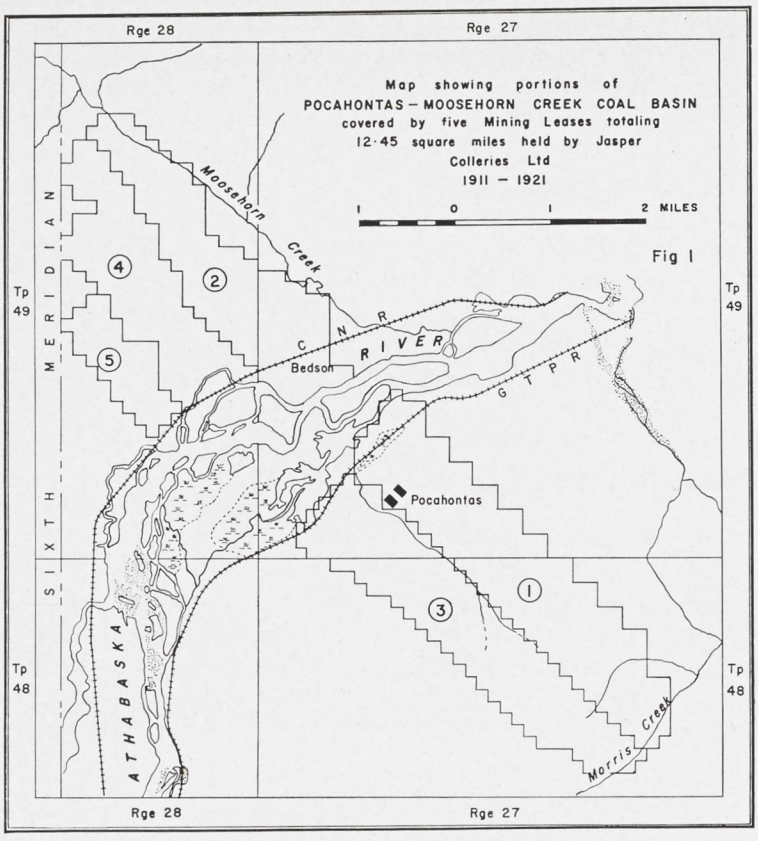


PLATE 2.

View from Pocahontas looking northwesterly across Athabasca River and up Moosehorn Creek valley, showing outcrop of Cadomin conglomerate formation near river and the high Palaeozoic ranges that border the valley on the east and west.

connected by a spur with its temporary tipple. The first car-load of coal was delivered to the railway company in the last week of September, 1911. The coal was extracted by a tunnel that ran along the strike of a steep westerly-dipping 10-foot thick seam for a distance of over 2,000 feet, where a vertical depth of coal of over 200 feet was attained. The entry to the seam was at the top of the gravel-faced terrace that lay about 270 feet above the tracks, and the coal cars, loaded in the tunnel at chutes, were drawn to the top by horse, and then lowered by cable and hoisting engine on an outside slope to the temporary tipple at the siding.

The construction of the Canadian Northern Railway along the north side of Athabasca River in 1914 offered an additional market for the coal and resulted in the Company opening up a colliery on the north side of Athabasca River near Bedson station. Both railways continued in operation until 1916, when through their amalgamation as a Government-sponsored Canadian National Railway, a single line was established and the rails of the other removed. In this section of the Pass, it was the Grand Trunk Pacific Railway line on the south side of Athabasca River that was abandoned, and its tracks east of Pocahontas removed for shipment to France for military requirements. This necessitated coal from the Pocahontas colliery being shipped westward to Jasper Park station for redistribution. With the loss of its eastern market, the management of Jasper Park Collieries claimed they could no longer continue to operate the coal mine profitably. Accordingly, in August, 1921, after extracting a total production of 840,200 tons, they closed down the mine, applied for compensation to the Government-sponsired railway, and relinquished all their leases with the exception of a 10-acre lease on which were located their buildings and machinery. This small lease was retained until April 11, 1932, when it too was surrendered.



It is questionable whether the removal of the G.T.P. railway line east of Pocahontas was the real cause of the coal mine at Pocahontas being closed down. The real reason appears to have been a combination of adverse factors. Among these was the severe folding and thrust faulting to which the coal measures and their contained coal seams had been subjected, which resulted in a large percentage of the mine output being in a pulverized condition, and thus restricted in its market. Furthermore, much of the coal was in a weathered condition due to the shallow overburden, and mining to depth was hampered by thrust faults. Another serious factor was that in places, the coal seams contained soft coal and carbonaceous shale, locally designated as "blackjack," which is high in ash and is difficult to distinguish from coal, but must be removed by careful mining and picking in order to reduce the ash content of the commercial product to the allowable percentage. The loss of the eastern market through the removal of the G.T.P.R. tracks was the last straw that broke the camel's back.

FIELD INVESTIGATIONS

The Pocahontas-Moosehorn Creek coalfield was investigated in 1910 and 1911 by D. B. Dowling[3, 4] when extensive prospecting, sampling of the coal seams, and development work were under way, and the interested reader is referred to his reports for detailed information pertaining to stratigraphy and structure and the chemical analyses of the various minable coal seams. Unfortunately Dowling did not compile any geological map of the coal field, but his 1910 report is accompanied by a "Topographical Sketch of a Portion of Jasper Park," on an appropriate scale of 1 inch equals 2.8 miles, and a stereogram of 17 sketch sections across the area drawn to the same scale.

When the writer investigated this coalfield in 1927 as part of his general mapping program of the Foothills coalfields, mining operations had long ceased, and the only evidence of what was once a flourishing colliery were the cavings of the tunnels and underground workings (PLATE 1), a couple of abandoned mine buildings, and a temporary Post Office (PLATE 3). The colliery, with its brief period of operation, was regarded as an unprofitable venture, and the field had been relegated to one mainly of scientific and historical interest. The writer undertook the mapping of the field mainly with the view of familiarizing himself with the main features of its stratigraphy and structure for correlation with those of the Brûlé coalfield, 7 miles to the northeast, which was then in the process of being abandoned, and with the Thoreau Creek coal deposits which, located near the headwaters of Wildhay River, 32 miles northwest of Pocahontas and in the same structural trough, were in the stage of being thoroughly prospected.

PREVIOUS LITERATURE

As a base for his geological investigation and mapping, the writer used the 'Map of the Central Part of Jasper Park' compiled from photographic surveys by M. P. Bridgland, 1915, and published by the Department of Interior on a scale of 1 inch equals 1 mile with a contour interval of 100 feet. Salient features from this map have been incorporated in the geological map presented in Fig. 2 (kindly drafted by F. Prebble of Canpet Exploration Ltd., Calgary) without any revision as to omitting the Grand Trunk Railway, or adding the main motor highway that occupies



PLATE 3.

The Post Office and Post Master at Pocahontas, 1927.

its roadbed and the branch motor scenic highway from Pocahontas to the Miette Hot Springs which replaced the old horse trail.

When the writer mapped the Pocahontas-Moosehorn coal basin, he extended his surveys eastward across the 6-mile wide area of Lower Mesozoic and Paleozoic formations to the Brûlé coalfields. The geological structure in this area is shown in Fig. 5a, b. No attempt will be made in this paper to describe the stratigraphy and structure of this belt beyond the brief note given in the map legend. For detailed description of these formations and their structiure, the interested reader is referred to the paper by J. A. Allan, P. S. Warren and R. L. Rutherford[1], which is accompanied by a structural profile section on a scale of 1″ equals 2½ miles. The most recent detailed study of this intervening belt is that by A. H. Lang[10] who mapped the Brûlé and Entrance map-areas in 1944 and 1945. The Paleozoic formations in this section of Jasper Park were also described by P. E. Raymond[17]. Their fossil faunas were discussed by Kindle[8], while James McEvoy[15] in 1901 described the geology and natural resources of the region. Data pertaining to the Paleozoic formations and the general geology of the area is also to be found in a popular booklet by E. M. Kindle, 1929, entitled "The Geological Story of Jasper Park"[9], and in a booklet by the writer "Geology of the National Parks of Canada in the Rockies and Selkirks" 1940 and 1952[13].

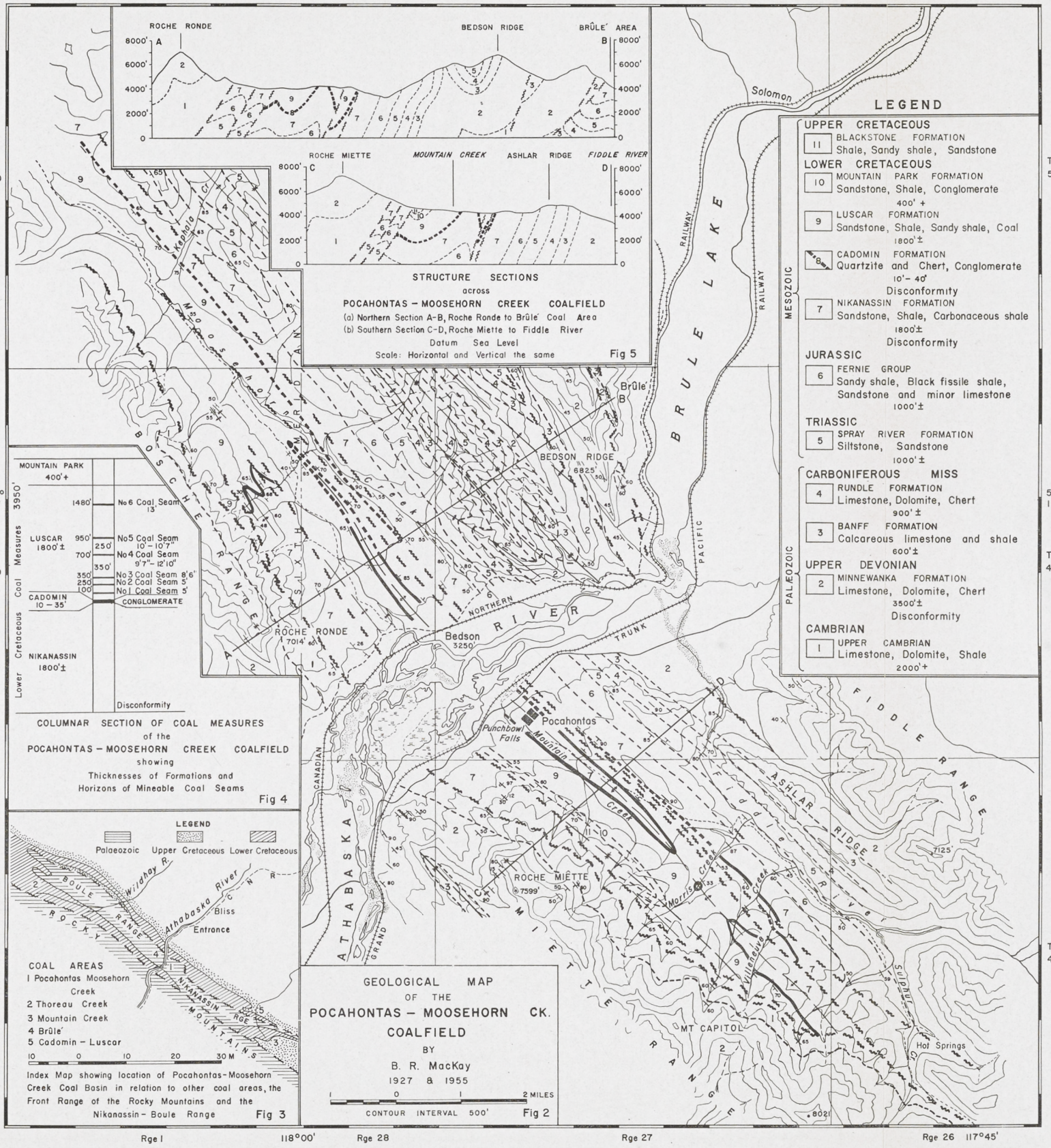
STRATIGRAPHY OF THE COAL MEASURES

Due to the thick deposits of glacial drift and stream alluvium that cover the bottom of the Pocahontas-Moosehorn intermontane valley, to the accumulation of talus from the eastern slopes of the Miette and Bosche Ranges, and to the soft nature of the Lower Cretaceous coal measures, rock outcrops in the valley are relatively few and are confined almost wholly to the deeper stream channel and to a few conspicuous hard beds. Nowhere within the coal basin is a complete section of the coal measures or of the individual formations to be had, and the estimated thicknesses have been computed from instrumental measurements connecting partial sections and across concealed stratigraphic intervals.

Before describing the individual formations, it may be well to refer to the history of the subdivision of these Lower Cretaceous coal measures. The name "Kootenai Series" was first applied to the Lower Cretaceous coal-bearing rocks of the Canmore and Crowsnest regions in 1886 by G. M. Dawson[2], who pointed out that the lower part of the series contained marine fossils of probably Jurassic age. In 1913, William Leach[11] in mapping the coal deposits of the Blairmore area, separated the upper non-coal-bearing part of the series from the productive measures, and named it the Blairmore formation. He placed the base of the formation at the bottom of a conspicuous bed of conglomerate, which he designed "the Kootenay conglomerate," and which later was named "the Blairmore conglomerate." As geological mapping along the Foothills belt proceeded northward, the name 'Kootenay' was applied to the coal-bearing portion of the Lower Cretaceous coal measures. This designation ultimately extended to beyond the Smoky River on the assumption that the Lower Cretaceous coal deposits of the Foothills belt were all of the same age.

When the writer began the mapping of the Mountain Park coalfield in 1924, he found that the coal measures contained a hard massive conglomerate very similar to that of the Blairmore coalfield and which he regarded as the equivalent of it. Here, however, the productive coal measures lay above the conglomerate, whereas at Blairmore they lay beneath it. It was a question, therefore, whether the conglomerate was the

CENTRAL JASPER PARK, ALBERTA



equivalent of that at Blairmore, in which case the coal deposits were of different age, or whether the coal deposits were the same age and the conglomerates represented different horizons. With the object of determining the age of the coal deposits of the Mountain Park and other northern fields, collections of fossil flora were obtained at all these coalfields from both the productive and non-productive measures. An examination of these collections by W. A. Bell, and later confirmed by other paleobotanists, established a Blairmore age for the conglomerate and overlying productive beds, and a Kootenay age for the underlying non-productive beds.

With respect to the subdivision of the Lower Cretaceous coal measures of the Foothills, the writer cannot do better than quote his conclusions formulated while mapping the Mountain Park and adjacent foothill coalfields:

> "The detailed mapping of this and the adjoining coal areas brought about a further subdivision of the rocks embraced in Malloch's[14] Kootenay. The most conspicuous member of the Lower Cretaceous group of sediments in this part of Alberta is a massive bed of conglomerate, three feet to seventy-five feet in thickness, composed of pebbles of quartzite, chert, and vein quartz, which are so firmly cemented in the siliceous matrix, that, when the rock is broken, the fractures cut through pebbles and maetrix alike instead of freeing the pebbles. On account of its great resistance to weathering this bed, even when thin, stands out above the surrounding strata, often forming pronounced scarps thirty feet or more in height [see PLATES 4 and 5]. This conglomerate bed proved to be so persistent, so unique in its uniform composition and ridge-forming tendency, and so useful in unravelling and portraying the complicated structures of the coal measures, that it was mapped by the writer as a separate lithological unit in the Mountain Park basin, and has continued to be so mapped in the more recent surveys of the fields further north. The selection of this bed as a separate mappable unit has been amply justified by its widespread



PLATE 4.

Outcropping 33′ bed of Cadomin conglomerate formation on north side of Athabaska River one-half mile northwest of Bedson on eastern flank of Pocahontas anticline, dipping 45 degrees northeast, with overlying coal-bearing Luscar formation on right, and underlying non-productive Nikanassin formation, that forms the core of the anticline, on left.

economic application as the main horizon in locating and tracing the commercial Lower Cretaceous coal seams, all of which, in this district, occur in the measures lying immediately above it. This is the 12-foot thick bed of conglomerate recorded by Malloch in his Kootenay section, lying 1,567 feet above the base and 2,080 feet below the top of the formation"[12].

By mapping this bed and the upper non-coal-bearing part of the series, the Lower Cretaceous coal measures of the district were divided into four lithological and mappable units, designated after the localities where they were best exposed or first studied by the writer. In descending order they are: (1) Mountain Park formation; (2) Luscar formation; (3) Cadomin formation; (4) Nikanassin formation.

As the investigation and geological mapping were extended northwesterwards along the Rocky Mountain front between the Brazeau and Smoky Rivers, the above four lithological units into which the lower Cretaceous non-marine sediments were divided could be easily delineated, except in the Folding Mountain and Brûlé coal areas. Here, largely owing to the thick mantle of boulder clay and alluvium, and partly to the loss of its characteristic ridge forming tendency, the Mountain Park formation, though recognized, was not clearly defined, and, in the mapping of these areas, was included with the Luscar formation.

In the Pocahontas-Moosehorn Creek coalfield all four formations are present, but the Mountain Park formation is so poorly defined and covers such a small area that it possibly should again have been included in the Luscar formation. However, due to its characteristic, rusty brown weathering, cross-bedded sandstones, its conglomeratic lenses and olive-green weathering sandy shales, and its lack of coal seams, it was retained as a separate formation with an estimated thickness of 400 feet. The uppermost beds in the section that lies immediately to the east of the thrust fault, and stratigraphically above the horizon taken as being the top of the Mountain Park formation, consist of interbedded sandy and black fissile shales with occasional concretionary thin ferruginous limestone beds that closely resemble the basal beds of the Upper Cretaceous Blackstone formation of the Prairie Creek and Brûlé areas, and were considered to be their equivalent. The thickness of the strata designated as Blackstone was not determined, but at best it was only a few hundred feet.

The Lower Cretaceous coal measures of the Pocahontas-Moosehorn Creek structural trough have been much deformed by folding and faulting along a northwesterly trending axis, and especially by the great over-thrust of the fault block that constitutes the Miette and Bosche Ranges. As a result of this, the formations are exposed in long and relatively narrow northwesterly trending structures and belts, as may be observed from the geological map (Fig. 2).

NIKANASSIN FORMATION

The Nikanassin formation overlies with a slight disconformity a thick succession of interbedded fine grained quartzitic sandstones and black crumbly and fissile shales, which constitute the Fernie group of Jurassic age. The Nikanassin consists of a succession of dark grey-buff to dark brown-weathering sandstones in beds up to 50 feet in thickness, interbedded with shale, sandy shale, thin beds of ferruginous limestone and an occasional thin bed of carbonaceous shale or impure coal.

As may be noted from the map, the Nikanassin formation occurs in three separate areas. The most extensive of these is the belt that extends along the northeast flank of the Pocahontas-Moosehorn Creek trough, lying immediately east of the Cadomin

conglomerate from Kephala Creek south to Sulphur Creek. The second belt forms the anticlinal core of the Pocahontas structure that extends from a little beyond the Sixth Meridian south-southeastwards, through Pocahontas to the northern branch of Morris Creek, a distance of 8½ miles. The Nikanassin reappears as a small exposure on the crest of the anticline in the main channel of Morris Creek. About a mile farther to the southeast, on Villeneuve Creek, it again reappears on the northwesterly plunging nose of the anticline, and continues for a distance of about 2 miles to the headwaters of a tributary of Sulphur Creek. The third belt is a wedge-shaped fault block of Nikanassin formation that starts from the Miette Range overthrust at the headwaters of Villaneuve Creek, and extends northwestwards in faulted contact with Cambrian strata on the southwest and the younger coal measures on the northeast. At Athabasca River it has a width of outcrop of about 3500′ and it retains this width for a distance of 3½ miles where it disappears beneath the Cadomin conglomerate.

The Nikanassin formation has an estimated thickness, based on graphical measurements, of 1800′. The most reliable section is along the lower course of Moosehorn Creek.

CADOMIN FORMATION

The Cadomin formation consists generally of a hard, massive, resistant, light-coloured conglomerate, composed of water worn pebbles of quartzite, chert, and vein quartz of various shades of green, red, grey, white and black. These pebbles, which range up to three inches in diameter, are so firmly cemented in the siliceous matrix that, when the rock is broken, the fractures generally cut across the pebbles and matrix alike without freeing the pebbles. This formation has a thickness within the area of from 10′ to 40′ and an average thickness of 35′ (see PLATE 4). Due to its resistance to weathering, it forms prominent outcrops along the eastern side of the Pocahontas-Moosehorn trough, on the rim of the Pocahontas anticline and at the northern plunge of the western fault block. It is in this bed that the famous Punchbowl Falls at Pocahontas are developed (PLATE 5). As the most conspicuous outcropping formation, it proved serviceable in separating the productive from the non-productive portions of the field, and as the datum from which the relatively few, but widely distributed, coal outcrops were measured and their horizons determined and correlated. The Cadomin conglomerate is separated from the underlying sandstones and shales of the Nikanassin formation by a slight disconformity.

LUSCAR FORMATION

The Luscar formation is the coal-bearing formation of the Lower Cretaceous coal measures. It consists of a succession of soft, grey and dark grey, thin-bedded, carbonaceous shales with several thin conglomerate beds, and at least six coal horizons. This formation occurs within the coalfield as two belts that are separated by the Pocahontas anticline and generally referred to as the eastern and western portions of the coalfield. The eastern portion is in the form of a tightly compressed and faulted trough that extends from Villeneuve Creek northwestwards to beyond the Sixth Meridian, its center passing ¼-mile east of Pocahontas and Bedson on the north side of Athabasca River. Beyond the Sixth Meridian, the eastern portion of the field is in the form of a southwesterly dipping monocline with an average dip of 65 degrees.

The western portion of the coalfield is less disturbed, and may be regarded as extending from the Cadomin conglomerate on the Pocahontas anticline west to the major fault-plane along which the non-coal-bearing Nikanassin formation has been brought

to the surface. It starts where the Cadomin conglomerate joints this thrust fault at the headwaters of the tributary stream that enters Sulphur Creek from the west, and gradually widens in a northwesterly direction to Morris Creek, where it has a width of 4000′. It retains this width northwestwards to Athabasca River and thence to beyond the Sixth Meridian, where it broadens out to more than double the width due to the northwesterly plunge of the structures that carries the Cadomin conglomerate below the surface.

Nowhere within the coal basin was it possible to secure a complete stratigraphic section of the Luscar formation, and the estimated thickness of 1800′ is based on instrumental measurements between the Cadomin conglomerate and the Mountain Park formation at a number of localities south of Pocahontas. The details pertaining to the coal seams in the formation are given later under the section on economic geology.

MOUNTAIN PARK FORMATION

The Mountain Park formation comprises the uppermost non-coal-bearing section of the Lower Cretaceous coal measures. It consists of grey, olive green weathering, sandy shales, coarse grey sandstones and thin beds of conglomerate composed mainly of small pebbles of black and green chert embedded in a sandy matrix. The formation only occurs in the area south of Athabasca River along the lower slopes of Roche Miette, extending from the gravel terrace of the river 3½ miles to the headwaters of Morris Creek. The thickness of the formation is estimated to be at least 400′. It is overlain by a thickness of a few hundred feet of sandy and fissile shales that are taken as belonging to the Blackstone formation of Upper Cretaceous age.

STRUCTURAL GEOLOGY

The Pocahontas-Moosehorn coal basin lies in a structural trough between the Front Range of the Rocky Mountains and the outlying Nikanassin-Boule range (PLATE 2). It is in the same structural relationship to these ranges as is the Mountain Park coal basin, 30 miles to the southeast of Pocahontas. Between these two basins, there is a 15-mile interval along the Rocky Mountain thrust fault that is underlain by Lower Mesozoic and Paleozoic rocks. It is from this area of greatest differential uplift and maximum thrust that the outlying ranges and the intermontane basins plunge in opposite directions (see Fig. 3). Prior to the development of the mountain structures, the Pocahontas-Moosehorn coal basin and the Mountain Park coal basin former a continuous deposit of Lower Cretaceous coal measures.

The Pocahontas-Moosehorn basin starts against the major upthrust fault of the Front Range of the Rocky Mountains, here named the Miette Range, at a point about 9 miles south of the Athabasca Aiver. It widens rapidly to a width of 1½ miles at Villeneuve Creek, and at Athabasca River it has its maximum width of 2½ miles. It retains this width up Moosehorn valley for a distance of 4 miles, and then narrows gradually toward the divide between Moosehorn valley and Rock Lake valley. Traced northward, it attains a width of almost 4 miles at Thoreau Creek near the headwaters of Wildhay River, and the belt continues to widen with the northwesterly plunge of the structures, until it ultimately swings around the northwestern spurs of the Boule Range to merge with the outer Foothills belt of Lower Cretaceous coal measures. The Thoreau Creek coal field lies 30 miles northwest of Pocahontas. It has been thoroughly prospected, but no development work has been done in it.

The most conspicuous geological structure within the coal basin is a northwesterly trending anticline, the axis of which emerges from beneath the Miette Range



PLATE 5.

Punchbowl Falls on Mountain Creek at Pocahontas showing channel and basin hollowed out on face of 33′ thick hard resistant Cadomin conglomerate formation by the erosive action of water and entrapped swirling boulders.

overthrust near the headwaters of Sulphur Creek. It passes through Pocahontas, across the Athabasca River, and up Moosehorn valley for a distance of at least 3 miles, where it crosses a tributary creek that enters Moosehorn Creek from the west at the Sixth Meridian. This structure is known as the Pocahontas anticline. It is a drag-fold developed on the western flank of the highly disturbed Ashlar and Bedson Ridges, and throughout its length is separated from the main westerly dipping coal measure belt by a tightly compressed syncline with at least one thrust fault.

The Pocahontas anticline is most clearly defined by the outcrop of the Cadomin conglomerate which separates the underlying non-coal-bearing beds from the overlying Luscar formation in which occur all the coal seams of minable thickness. This anticlinal structure divides the Pocahontas-Moosehorn Creek coal basin into two parts, a narrow compressed and faulted trough lying immediately east of the Pocahontas anticline, and a less disturbed westerly dipping limb, about ¾-mile in width, lying between the conglomerate and a major thrust fault on the lower slopes of Miette and Bosche Ranges. Close to this fault, the beds are folded back to form a subsidiary syncline, but, at the fault itself, they appear as westerly dipping beds of a secondary anticlinal drag-fold. The axes of these two folds are best observed in the upper valley of Morris Creek.

Immediately west of this fault is a wedge-shaped fault block of upthrust Nikanassin formation, that starts as a thin wedge at the headwaters of Villeneuve Creek and attains a width of ¾-mile at Athabasca River. It continues with about this same width northwestwards for a distance of four miles to the tributary creek that joins Moosehorn Creek from the west at the Sixth Meridian. On the upper part of this creek, the northwesterly plunging drag-folds on the Cadomin conglomerate and the structures in the intervening area indicate that the strata exposed further southwest in the fault block belong to the non-productive measures beneath the conglomerate. The disturbed condition of the coal measures in the southwestern half of the creek, 1½ miles northwest of the Cadomin outcrops, strongly suggests that the major thrust fault that forms the eastern boundary of the Nikanassin formation continues northwestwards from Athabasca River for a distance of at least 7 miles. Beyond this, it likely is overridden by the major thrust of the Bosche Range. If such be the case, the eastern portion of the productive coal measures would be expected to extend from the Sixth Meridian northwestwards as a monocline with an average westerly dip of about 65 degrees, and an average width of 1 mile.

ECONOMIC GEOLOGY

Due to the severe thrust faulting and subsequent erosion to which the coal measures and their contained coal seams have been subjected, and to the thick mantle of boulder clay and alluvium or deposits of talus that occur along the lower slopes of the Miette and Bosche Ranges the outcrops of the coal measures are so few and so incomplete that it was found impossible to be certain of the number of coal horizons that occur in the Luscar formation, or of the correlation of the coal seams that were observed at widely separated localities. Coal seams were observed by Dowling and the writer at six different horizons above the Cadomin conglomerate, but differences in stratigraphic position do not necessarily indicate a different seam, as the horizon may have been modified by the thinning or thickening of beds and by thrust faulting or folding. The six coal horizons described are indicated on the accompanying columnar section (see Fig. 4). They are numbered in ascending order with their observed thicknesses and the intervening stratigraphic intervals.

Seam No. 1. This coal horizon lies approximately 100 feet stratigraphically above the Cadomin conglomerate. The seam was observed at a number of localities, but does not appear to be continuous over any great area. On the south side of Athabasca River, a 5′ thick coal seam was observed at this horizon in the gully of a small stream that cuts through the east flank of the Pocahontas anticline at a point about ½-mile southeast of the collieries. A coal seam of about the same thickness and at about the same horizon was observed on both flanks of the Pocahontas anticline on the north side of Athabasca River, 1 mile to the northwest of Bedson. Four miles to the northwest of Bedson, a 5′ coal seam was observed lying approximately 100′ above the Cadomin conglomerate where the latter forms the limbs of four northwesterly plunging drag-folds crossed by the tributary stream that joins Moosehorn Creek near the Sixth Meridian.

Seam No. 2. This is a 5′ thick seam that outcrops on Villeneuve Creek, 5 miles south of Pocahontas, at a horizon 250′ stratigraphically above the Cadomin conglomerate. As this was the only locality at which coal was noted in this position, instead of being a separate seam, it may represent the same horizon as seam No. 3, which outcrops ¾-mile to the northwest.

Seam No. 3. This is an 8′6″ thick coal seam that outcrops on Morris Creek at a horizon 350′ stratigraphically above the conglomerate. It consists of two benches of coal separated by a 2′ thick bed of sandstone; the lower coal bench is 3′ thick, and the upper coal bench is 5′6″ thick. Again, it may be that this two-bench coal seam corresponds to the 5′ thick coal seam No. 2 of Villeneuve Creek.

Seam No. 4. This is generally designated as the Tunnel seam, as it is in this seam that the main development tunnel at Pocahontas was driven. At the tunnel, the coal seam averaged 12′10″ thick, and consisted of two benches separated by a 1′-2′ thick bed of sandstone, the lower bench being 3′4″ thick and the upper bench 9′6″ thick. Dowling gives the stratigraphic interval between this coal seam and the conglomerate as 414′, as determined by a dip of 56 degrees to the southwest and a horizontal distance between their outcrops of 500′. This is considerably less than the interval the writer obtained in carrying a traverse along the conglomerate and tying in the surface cavings of the Tunnel seam, but this difference may be in part due to the thickness of the gravel deposit that forms the high terrace over the coal seam. However, Dowling correlates the tunnel seam with the 12′ thick seam on Villeneuve Creek. and shows by his section that the latter lies approximately 700′ stratigraphically above the conglomerate. This accordingly is taken as the interval between the conglomerate and No. 4 seam. On Morris Creek, a 9′7″ coal seam lying 650′ stratigraphically above the conglomerate is regarded as the same horizon.

Seam No. 5. This seam outcrops on both Morris and Villeneuve Creeks at a horizon 250′ stratigraphically above Seam No. 4, or approximately 900′ stratigraphically above the Cadomin conglomerate. On Morris Creek, the coal seam has an observed thickness of 10′11″, and is made up of two benches of coal separated by a 6″ thick bed of shale; the lower coal bench is 7′1″ thick, and the upper bench is 3′10″ thick. On Villeneuve Creek the coal seam has a reported thickness of over 10 feet.

Seam No. 6. This is a 13′ thick coal seam, reported by Dowling as outcropping on the lower slope of Roche Miette at a distance of 1050′ to the west of the Tunnel seam and approximately 870′ stratigraphically above it. If we accept Dowling's correlation of the 12′ Villeneuve seam with the Tunnel seam (No. 4), then the interval between the

Cadomin conglomerate and this upper seam (No. 6) is 1570′. This is the highest recorded coal horizon in the area, and it is estimated to lie 230′ below the horizon that was taken by the writer as marking the base of the Mountain Park formation.

The foregoing six coal horizons pertain largely to the part of the coal-field lying to the south of Athabasca River. In the northern part of the coalfield, the coal measures are more highly folded and faulted and the exposures are largely masked by stream alluvium, so that it is more difficult to determine the number of seams present and the stratigraphic intervals between them. On the western limb of the Pocahontas anticline, five seams outcrop above the Cadomin conglomerate, but some of these are believed to be repeats by folding and faulting. One, which appears to be the northwesterly continuation of the Tunnel seam at Pocahontas, has an outcrop thickness of 11′7″, and below this, and between it and the conglomerate, a 5′ seam is reported. These coal horizons are also present on the east flank of the anticline.

Coal seams of workable thickness were also observed along the upper part of the gully that enters Moosehorn Creek near the Sixth Meridian. These embrace a 14′8″ seam, a 6′10″ seam and a 5′9″ seam, lying respectively 163′, 232′, and 424′ stratigraphically above the Cadomin conglomerate, and it is highly probable that higher seams occur in the overlying drift-covered coal measures to the northwest of the Cadomin conglomerate outcrops.

QUALITY OF COAL

The analyses of samples of coal from the mine workings and from surface prospects of most of the aforementioned coal seams were made when the field was being opened up and under development. Practically all of these analyses indicates the coal to be a 'low volatile bituminous coal,' which, on a dry ash-free basis, had a fixed carbon content ranging from 68.66% for surface outcrop coal to 78.83% for fresh lump coal from the mine workings, and a corresponding volatile content of 31.34% for the surface outcrop coal, and 21.17% for the fresh lump coal. Most of the samples taken within 30′ of the surface show the effects of weathering in the softening of the coal through oxidization, and the crumbling of the coal through the development of a network of closely spaced fractures. In the mine workings also, much of the coal, when extracted, was in powdered form and, at best, was only poorly coking, so that it was unsatisfactory for locomotive use.

CONCLUDING STATEMENT

No mine plans are available to show the extent of the underground workings at Pocahontas, or on the north side of the Athabasca River; but it is known that most of the mining was concentrated south of the river in the Tunnel seam, extending along its strike from the tipple southeastwards for a maximum distance of 3 miles, and to a depth of only a few hundred feet. On the north side of the river, mining development was confined to the immediate vicinity of the river, and the small easily available reserves did not warrant the installation of more than a temporary plant. The productive coal measures in this part of the field occur on the two limbs of the Pocahontas anticline, in which the coal measures are characterized by folding and faulting and subsequent erosion. Over most of this belt, this has resulted in the coal being confined to shallow folds, with little coal to be had either above or below tunnel level.

Any possibilities that the Pocahontas-Moosehorn coalfield may possess with respect to its unexploited seams are confined largely to the area lying south of the Atha-

basca River and to the west of the Tunnel seam. There is, however, little prospect of coal mining in this field ever being resumed, as it is located within the boundaries of Jasper National Park, and, under the National Parks Act of 1930, prospecting for and the development of minerals within the Park is not permitted.

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FIELD TRIP LOGS

H. W. WOODWARD*

INTRODUCTION

The accompanying road logs and plates have been prepared as guide material for geologic field trips in the Jasper area, and on the route between Jasper and Banff. The specific routing of separate trips to be conducted on Saturday and Sunday, September 17th and 18th, 1955, is contingent upon arrangements yet to be made with Park authorities and transportation services. In general, the Saturday field trip will consist of selected stops on the routes of road logs 1A to 1E, which will provide the opportunity for first-hand examination of the component parts of the geologic section exposed in the Jasper area. The Sunday trip, road log 2, is provided for those who elect to travel to Banff either by bus or in motorcade. As this is a long trip, only two stops will be made.

A summary has been prepared for each log so that those who visit the Jasper area subsequent to the planned trips may better select the route exposing stratigraphy or structure that will suit their interest.

The material for the road logs has been obtained in part from those publications listed in the bibliography, and in part from ten days preliminary field work conducted by the writer and his assistant in late May and early June, 1955. Areal geologic control along the several routes is sparse and has necessarily been extrapolated extensively, mostly by roadside investigation and binocular study. The pressure of commercial work unfortunately made it impossible to complete the photogeologic analysis prior to submission of the road logs for publication. It is expected, therefore, that some discrepancies will result; it is hoped that these will be only minor.

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Messrs. R. B. McCulloch and C. Wright-Broughton of Miller and McCulloch, Calgary, prepared the photogeologic map, plate 10A, and Messrs. J. Alliger, R. L. Hughes, F. C. Brechtel, J. F. Conrad, L. E. Swayne, and C. B. Geisler of Geophoto Services, Calgary, prepared photogeologic maps, Plate 10B. Aerial photographs for the area were loaned by Canadian Gulf Oil Company and several aerial mosaics for the Jasper area were obtained from Stanolind Oil and Gas Company, Calgary.

Control for the photogeologic interpretation for small parts of the mapped area was obtained from the publications listed in the bibliography, from unpublished information obtained from Professor L. R. Laudon of the University of Wisconsin, and from R. L. Hughes, of Bullock and Hughes Petroleum Geologists, Ltd., Vancouver.

Canadian Gulf Oil Co. drafted Plate 1, and Canadian Stratigraphic Services Ltd., Calgary, drafted Plates 2A and 2B. Photographs are by A. H. Ellison, L. M. Clark, and M. K. Sorensen. R. G. Edwards, a senior student at the University of Saskatchewan, was a helpful companion on several trips through the Jasper area in May and June. F. K. North, G. E. Hargreaves and R. B. McCulloch edited parts of the road logs.

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PLATE I
ALBERTA SOCIETY OF PETROLEUM GEOLOGISTS
FIFTH ANNUAL FIELD CONFERENCE
SEPT. 1955
INDEX MAP OF JASPER AND BANFF NATIONAL PARKS SHOWING ROUTES OF ROAD LOGS Nos. IA, IB, IC, ID, IE, AND 2
SCALE 4 3 2 1 0 2 4 6 8 10 12 MILES
HINTON
FOLDING MT.
FIDDLE RANGE
MIETTE HOT SPRINGS
BODLE RANGE
MIETTE RANGE
BOSCHE RANGE
DE SMET RANGE
JACQUES RANGE
COLIN RANGE
THE PALISADE
JASPER
JASPER LODGE
MALIGNE MOUNTAINS
LE GRAND BRAZEAU
ENDLESS CHAIN RIDGE
SUNWAPTA PASS
YELLOWHEAD PASS
TETE JAUNE
GOLDEN
LAKE LOUISE
BANFF
BOW PASS
WAPUTIK RANGE
SAWBACK RANGE
BOURGEAU RANGE
FAIRHOLME MOUNTAINS
SULPHUR MT.
GOAT RANGE
CASCADE MT.
MT. RUNDLE
THE THREE SISTERS
PIGEON MT.
SEEBE
Athabasca River
Maligne Lake
Medicine Lake
Rocky River
Jacques Lake
Snake Indian River
Moose Lake
Fraser River
Bush River
Columbia River
Vermilion Pass
Kicking Horse Pass
Bow Lake
Bow River
Cascade River
Red Deer River
Ghost River
Brazeau River
Athabasca Pass
Mt. Robson
Mt. George Graham
Mt. Fitzwilliam
Roche Noire
Mt. Edith Cavell
Whirlpool Pk.
Mt. Fryatt
Mt. Christie
Brussels Pk.
Dragon Pk.
Catacomb Mt.
Diadem Pk.
Mt. Alberta
Stutfield Pk.
The Twins
The Snowdome
Mt. Kitchener
Mt. Athabaska
Mt. Castleguard
Mt. Saskatchewan
Mt. Coleman
Mt. Wilson
Mt. Murchison
Mt. Amery
Mt. Lyell
Mt. Erasmus
Mt. Forbes
Mt. Outram
Mt. Chephren
Mt. Sarbach
Mt. Kaufmann
Mt. Noyes
Observation Peak
Mt. Hector
Mt. Vaux
Mt. Temple
Mt. Eisenhower
Mt. Ibbex
Mt. Bourgeau
Mt. Brewster
Mt. Grotto
Mt. Gropard
Mt. Stephen
Mt. Burgess
Mt. Vaux
Mt. Hurd
Mt. Copper
Mt. Pilot
Mt. Massive
Mt. Bourgeau
Mt. Hurd
Mt. Vaux

PLATE 2A

SURFACE GEOLOGIC SECTION
EXPOSED ON PARTS OF ROUTE

ROAD LOG 1 JASPER AND VICINITY

Compiled by- H.W. Woodward, 1955 from Brown, R.C.A. (1952), deWit and McLaren (1950); Harker, P. et al (1954); Kindle, E.M. (1929) and Raymond, P.E. (1930).

Drawn by- Canadian Stratigraphic Service Ltd., Calgary, Alberta.

SYSTEM	FORMATION	MEMBER	MEASUREMENT	LITHOLOGY
JUR.	FERNIE			Sh, blk
TRIASSIC	SPRAY RIVER	WHITEHORSE	248	Dol, gr, msv, silty Dol, gr/tan, msv, cht Sh, gr, sdy, calc Ls, brec, bf, sdy & calc matrix; evaporites Sh, red, calc Covered Dol & ls, gr, msv, wi rare red sh & sdy sh inbd
		NEW TENTATIVE CORRELATIONS	450	Sh, brn/gr, calc, silty Dol, gr, silty Siltst, dk gr, lam, wea red, some random dk gr inbd sh Siltst, lt gr, hd, thin-bdd, bf/red wea
MISSISSIPPIAN	GREENOCK	ROCKY MTN.	63	Ss, calc, dk gr, v f, wea pk, gr & brn
		TUNNEL MTN.	139	Covered Cht, lt gr, msv, wea lt gr & rusty brn; inlam ss, dk gr f, wea red-brn Covered
		MOUNT HEAD	323	Ls, dolc chty, arg, bi-gr, lith may be silty Ls, dk gr, mcr-x/v f x, wea pale brn Covered Ls, gr, lith, wea wh, many foss cht nod cht nod unfoss
	RUNDLE	LIVINGSTONE	783	Ls, lt gr, mcr-x/fx, msv, wea lt gr, silty feel chty, wea lighter gr Siltst (?), calc, wea lt gr Ls, gr, f x, crin, coral, wea lt brn wi wh spec Ls, gr, m x, heavy bdd, por, msv, wea dk/lt gr Ls, x, crin, msv/bdd, pale brn, por msv Ls, gr, lith Ls, x, por, poorly bdd Ls, lith, much frac, silty feel, wea lt gr Ls, f x, pale brn, wea lt gr Ls, x, sft, por Ls, blue-gr, lith, por, wea lt gr, wh ca x in pores Ls, blue-gr/dk gr, f x, glist, silty feel, chty Siltst, gr, calc, partly covered Ls, dk gr, glist, f x, silty feel at top, corals, wea lt gr/lt brn Covered Covered Ls, gr, x, crin, blocky, poor bdd, wea gr, horn corals Ls, crs x, crin, sl por, msv, occas masses darker finer g, cht ls
	BANFF	UPPER	385	Ls, gr, f x, wea gr/bf Ls, almost blk, lith, wea gr Ls, fos gr, v silty, wea bf, pt cov Ls, foss, slimy, wea bf/rusty brn, foss loc sh, gr, paper-thin lam, wx, dk gr, sl foss Ls, gr, f x, foss, alternating wi sh, gr Ls, dk gr, arg, silty, foss, Ls, dk gr, x, foss, alternating dk splintery sh in lower pt Ls, dk gr, impure, crs x at top, f below, rare beds blk silty sh dk ch nods Sh, calc, dk blue-blk, alternating bf silty bands, chty in up half more strongly fractured, more uniformly shaly
		LOWER	174	Covered Ls, dk gr, msv, wea gr; alternating sh, dk gr, strongly fissile Covered
	EXSHAW		44	Sh, calc, thin bdd, alternating nod ls bands 1" apart Sh, arg, red-brn, rusty, m gr, carb wood frg, oval pel; cht nod; siltst Covered
DEVONIAN	PALLISER		865	Ls, dk gr/brn-gr, dns, dolomitic stringers, sl nod, crin, brach Ls, gr/dk gr, x/f x / dns, tr dolc, msv, pt faintly bdd, wea wh-gr; scat crin, brach, gast
	ALEXO		620	Ls, dk gr/gr, f x, alt stringers in nod bands; to ls, arg, silty, brach Siltst, calc or dolc, & silty ls, lt brn-gr/gr, cross-bdd Ls wi dissem silt, sl nod app, msv, Ls, silty, nod to faintly banded, faint ripple marks; siltst at top Ls, silty bands alternating wi more calc bands 1 to few inches thk Siltst & ls, strongly contorted because of slumping; Sh, calc; ls, arg, blk, thn-bdd, fri; Alspora, brach, fish frg; Sh, calc, blk, thn-bdd, sft, lower 5" sdy
	MT. HAWK		219	Ls, arg, lt/dk gr, f x, scat f silt; rythmic alternation of more calc beds 2" to 4" thk and more arg bands 1/2" thk; shy towards base; unfoss
	PERDRIX		357.5	Sh, calc, blk, sft, bf-gr wea Sh, sl calc, f silty, sft, bf wea; few thin frac wi solid bitumen Sh, sl calc, blk/dk brn, fri Sh, sl-/ non-calc, blk; 1' ls, silty & arg, blk; 3' ls, arg, dk gr Sh, calc, dk gr/blk, pt covered, Tent, brach, Buchiola
	FLUME	UP.	46.5	Ls, arg, dk gr/blk, dns/x, nod, cglc; tr sh; Spirifer jasperensis
		LOWER	162	Dol, dk/brn-gr, x, sug, calc, coral, brach, Amphipora(?), Strom, Ls, dolc, gr, dns, detrital, Strom; alternating dol, ls, wh, pk Dol, m/dk gr/blk, f / crs x, Amphipora(?) Dol, gr, f / crs x, msv, num wh spec, pt calc, pyr, few vugs Dol, blue-gr, dns, styl, platy, bf-gr wea Dol, dk gr, dns, pt arg & chty, v large Atrypa sp
ORDOVICIAN			850	Dol & qtzic ss Sh, olive gr, wi inbd magnesian ls, barren Covered Ls, thn-bdd, sub-x, small brachs, gast, & trilob com; "Ozarkian" Ls, hd, lam; inbd ls, magnesian, shy Ls, semi-lith, hd, in bands few ft thk separated by bands dk shy ls beautifully lam wi layers 1/16" thk or less; bands ls pebs or brec
NOTE: Adjacent section studied at separate localities; contact relationships unknown.				
UPPER CAMBRIAN			700	Dol, yl, cavernous, inbd grn sh Ls, shy, blue & gr, abd trilobites Magnesian ls, msv, dk gr, forms cliff sloping NW to road Ls, impure, nod, gr, trilobite frgs Underlain by sh, grn, poorly exposed

PLATE 2B

SURFACE GEOLOGIC SECTION
EXPOSED ON PARTS OF ROUTE

ROAD LOG 2 JASPER TO BANFF

Compiled by- H.W. Woodward, 1955 from Grey, C.E. (1951); Spreng, A.C. (1953); Severson, J.L. (1950); Walcott, C.D. (1928); Deiss, C. (1939) and Rosetti, F. (1951).

Drawn by- Canadian Stratigraphic Service Ltd., Calgary, Alberta.

SYSTEM	FORMATION	MEMBER	MEASUREMENT	LITHOLOGY
				(Eroded peak of Mt. Coleman)
MISSISSIPPIAN	RUNDLE		1115	Dol, blk, dns; indst ls, gr, dolc Ls, gr/blk, dns, alg, chty, cross-bdd Ls, gr, thn-bdd, dolc, mcr-crin, forms cliff Ls, dolc, blk, chty at top & bottom Dol, gr/blk, thn-bdd, foss Dol, gr/brn, msv, crg, crin Ls, gr, crs, much alg cht Ls, wh, crs Ls, gr/blk, crumbly, alg cht Ls, gr, crs/f, crin Ls, gr/blk, f, wi blk cht nod Thin beds alternate wi msv zones
	BANFF		1696	Ls, msv, cht Ls, msv, crs g Sh, dk brn, silty Ls, msv, inbd sh
	EXSHAW (?)		168	Ls, dk gr, arg, wea yl brn/bf Sandy ls, brown ss, & arg ls Siltst, blk, platy, non-calc, Two bands crs blk ls near base ("Exshaw" of Severson may be basal Banff siltstone)
DEVONIAN	PALLISER		1656	Ls, gr, foss, arg, blk cht nods Ls, blk/dk gr, arg, dns, blk cht, pt brec Ls, dk gr/blk, msv Ls, arg, blk, chty, few crin near base Ls, msv, dns, dk gr/blk, tr blk cht near top Ls, dns, gr, lower 16' v crin Ls, irreg bdd, dk gr Ls, irreg bdd, msv, dns, dk gr Ls, irreg bdd, m / dk gr, to brn & blk Ls, msv, crin, cl partings Ls, msv, gr down to blk Ls, irreg bdd, dk / m gr Ls, dns, f, brn/blk Ls, dns, m g, gr, many crin segs Ls, msv, dns, m g, gr, crin segs Ls, irreg bdd, dk gr Ls, msv, dk gr, blk cht in lower 5' Ls, dns, gr, msv at base Ls, irreg bdd/msv, dk gr Ls, dns, blk, v msv Ls, irreg bdd, dk gr Ls, irreg bdd, dk gr, silty, weathers back Ls, dk gr/blk, f g, largely msv Ls, dk gr, irreg bdd, silty above, grdg/brn below Ls, f g, brn, dns Ls, f g, dns, gr Ls, msv/irreg bdd, dk gr / blk, f g
	ALEXO		248	Ls, v sdy, mottled Ls, gry, sdy, sl cl at base Ls, sdy, almost qtzic ss at top; sdy / silty below; some dns/crs ls Ls, gr, sdy, lam, wea tan Sh, red/ brn, chty, grn & red sh pt & beds; red & grn siltst; pyr
	FAIRHOLME		1363	Dol, hd, msv, gr-Ls, gr, msv, top por iron stained, phos; Ls, blk, coralline, v fri at top, msv below, gr below Ls, gr, thin bdd/msv, crin at base Ls, gr, nod, blk ch nod Ls, blk/dk gr, nod, foss, corals; dol & crsl x gr is at base; pyr Ls, blk/gr, nod, cht, m / crsl x, Inbd blk x ls and v arg ls, H_2S odor when crushed Ls, blk, x, calcite-lined cavities, H_2S odor when crushed Ls, blk, x, few larger corals Ls, blk, msv, 2% to 5% por due to solution cavities Ls, blk, bdd, x, brec, H_2S odor when crushed Ls, blk, x, cavities up to 1' diam, about 15% porosity Ls, dk gr/blk, x, partly por, Strom, algal Ls, sft, f bdd, silty, blk Ls, blk/dk gr, chty, alg Ls, dk gr, dns, tr por beds, tr Strom Ls, silty, blk Ls, gr, pt argil, some por beds, blk arg at base Ss, limy, irreg bdd / x bdd, wh, qtz, some bf wea is dissem
SILURIAN (?)			82	Dol, dns, gr, msv, wea bf, tr pr, or crin, blk cht nod near base Ls, dolc, sdy, ss, wh, dol str/veins, qtz, phos nods near base
ORDOVICIAN	MT. WILSON		411	Ss, msv, x-bdd, wh qtz, v well cem wi wh qtz, tr arg at base
	SARBACH		1120	Ls, thick-bdd, gr, breaking up into layers of varying thk, (1 to 16 inches); thk est because of inaccessible cliffs Sh, drab-colored, arg, wea bf & yl, break down readily on wea
	MONS		975	Sh, calc, wi thin irreg layers ls, cpt, blue-gr; ls, semi-x, 2" to 12" thk inbd at irreg intervals Ls, dull gr, msv, much incl f aren matter giving wea surf a slightly roughened app
NOTE: Adjacent sections studied at separate localities; contact relationships unknown.				
UPPER CAMBRIAN	BOSWORTH		430	Ls, dk gr, f, sl fetid, thin-bdd, top beds oo Ls, dull gr, f, platy bdd, grdg down to nod bdd, dk gr Dol, gr, lam; ls "clinker" bed at top Ls, m / dk gr, arg Inbd ls, blk-blue-gr, msv, alg; dol, gr, s-lith Ls, blk-gr-blue-blk, f, msv, alg
	ARCTOMYS		270	Ls, blue-gr, f, impure; inbd dol, bf, thk-bdd; sh, grn, tan, gr Dol, alternate bright-bf-tan & maroon, pt, pt aren Ls, pale-gr f sdy Ls & dol, dull, dk & bf-gr, f; tr dol near top Sh, maroon, calc Sh, dk maroon, dolc, f aren, some grn & bf, salt casts Dol, gr, f,
?	PIKA		550	Dol, dk gr, f, thk bdd, wea wh/fingr & bf Covered Dol, dull-gr, thn-bdd, thker bdd & dker toward top, ls at base Dol, dull-gr, dk gr, & bf, top 6' forms prominent ledges Ls, gr, blue-gr, aren cl pt, pt oo, occas int-form cgl Dol, pale-gr, f/m g; pt arg, edgewise cgl
MIDDLE CAMBRIAN	ELDON		1015	Dol, dull-gr/ dk gr, f / m x, petrolif Dol, pale-blue-gr, f, vitreous Dol, dull, pk- & tan-gr, fetid Dol, dk-gr/blk-gr, m / f x Dol, wh-gr, crs/m x, msv Dol, dk gr/blk-gr, f / m x, thin-bdd, msv 5' bed at top
	STEPHEN		285	Ls, dull-gr/dk blue-gr, f/m g, pt arg, foss Sh, grn, grn-gr, bf, calc; intercalated ls, aren; foss; in-form cgl Sh, bf & dull gr, calc; intercalated ls, blk-gr, arg Inbd ls, blue-gr, dull-gr, dk-gr, & sh, calc, foss Ls, dull-gr, dk-blue-gr, thn-bdd, occas in-form cgl; trilobites
	CATHEDRAL		775	Dol, blk-gr, f, thn-bdd Dol, pale-gr, crs x, msv, forms upper cathedral cliffs Dol, blk-gr, f, extremely thk-bdd Dol, dk & lt gr, crs / m x, msv Dol, blk - & dull-gr mott, m g, styl, thk bdd at top only Dol, dull-gr, f, thn-bdd, forms bench, Ross Lake fossil beds at base Dol, steel-gr & bf mott, m g, msv Dol, wh-gr, stained pale-bf, crs x, thk-bdd Dol, pk-wh mott blk-gr, m x Dol, pale-bl-gr, some dk mott, crs Ls, blk-/dull-/blue-gr, f g, pt arg & aren, tr oo
	MT. WHYTE		145	Ls, blue-gr, crsl oo, trilobites; inbd ls, grn-gr, & sh, sdy: ss Sh, brg, mar, pale grn; pz, m / crs, some thin impure ls Sh, m/crs, gr/sh, mar/lah, some blk
LOWER CAMB.	ST. PIRAN		200+	Qtzite, msv, vitreous, wh & pale gr, cross-bdd; sh, pale-gr

NOTE: This sandstone sequence is underlain in the Bow, Sunwapta, Miette and Upper Fraser river valleys by rocks, several thousands feet thick, of similar lithologic types. These rock sequences have been alluded to differently as the St. Piran, Fort Mountain, Gog, Jonas Creek, McNaughton and Mahto formations. In the Bow and Sunwapta river valleys the Lower Cambrian series is underlain by the Proterozoic Hector formation.

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ROAD LOG 1A—HIGHWAY NO. 16, JASPER TO HINTON

SUMMARY

The route between Jasper and Hinton traverses the east margin of the Rocky Mountain Main Ranges sub-province and the belts of the Front Ranges and Foothills sub-provinces. Rocks representative of parts of the geologic sequence, Lower Cambrian to Upper Cretaceous, are exposed. Within the Front Ranges sub-province the weather-resistant ridge formers are the Palliser, Upper Banff and Rocky Mountain formations; identification of these on the mountains adjacent to the route provides the key to both stratigraphic disposition and structure. The Front Ranges in the Athabaska Valley are mostly complexly folded in contrast to simple fault blocks typical of these Ranges in other areas. The lithological log of geologic sections exposed on this route, Plate 2A, the annotated panorama of the Front Ranges, Plate 3, and photogeologic map, Plate 10A (in pocket), may be used jointly with the road log for guidance.

0.0 (49.0)	Canadian National Railway level crossing at southwest outskirts of Jasper; railway crosses continental divide at Yellowhead Pass, 18 miles directly west. This pass, with an elevation of 3,711 feet is one of the lowest passes across the Rockies on the continent.
0.3 (48.7)	East—Jasper Canadian National Railway Station and Jasper Park Information Bureau. West—Jasper Park Administration Building.
0.5 (48.5)	West—Roads lead four miles northward to Patricia and Pyramid Lakes and picnic ground.
0.9 (48.1)	West—Housing project at northeast corner of Connaught Drive and Bonhomme Street occupied by families of Trans Mountain Pipeline employees.
1.1 (47.9)	Outskirts of Jasper town.

1.4 (47.6) North—Terrace of lacustrine sands approximately 150 feet above road level.

1.6 (47.4) Canadian National Railway underpass

1.7 (47.3) South—Branch road to Cottonwood Creek camp ground and cabins.

1.8 (47.2) South—Signal Mt. (7,397 feet) at north terminus of Maligne Mountains, formed of Lower Cambrian and/or Proterozoic quartzites and argillites. Mountains are structurally continuous with Pyramid Mountain on north side of Athabaska River Valley. These several mountains, in the hanging wall of Pyramid fault of Castle Mountain fault zone, form easternmost range of Rocky Mountain Main Ranges sub-province.

2.1 (46.9) East—Mt. Dromore in Colin Range is former of Devonian and Carboniferous strata.

2.4 (46.6) Southwest—Good view of Mt. Edith Cavell (11,033 feet), prominent pyramidal peak, composed of over 6,000 feet of Lower Cambrian and/or Proterozoic sediments.

2.9 (46.1) East—Branch road to Jasper Park Lodge, Fish Hatchery, Maligne Canyon and Medicine Lake (Junction is Mile 0.0 on road log 1C).

3.0 - 3.4 (45.6 - 46.0) West—Road outcrop of Lower Cambrian quartzites which occur directly in hanging wall of Pyramid fault.

3.4 (45.6) Culvert of Pyramid Creek at approximate surface position of Pyramid fault of Castle Mountain fault zone. Along this fault zone, at this latitude, Proterozoic and Lower Cambrian strata of the Main Ranges sub-province are thrust upon Upper Paleozoic strata of westernmost range of Front Ranges sub-province.

3.5 (45.5) West—Road outcrop of deformed dark grey limestone and black shale located directly in foot wall of Pyramid fault. These rocks are apparently in a fault slice of Flume and Perdrix formations on west slopes of the Palisade.

3.6 (45.4) West—Small cliff, the uppermost part of which consists of banded argillaceous limestones, possibly of the Mount Hawk formation, possibly Banff formation. Fault relationship of these limestones to the subjacent Palliser limestones is exposed in transverse section in railway cut above.

3.8 (45.2) East—Colin Range, a compound structure composed of faulted parallel structure units of Mt. Hawk and Roche Bonhomme.

4.4 (44.6) Southeast—Valley of tributary Maligne River with Colin Range on northeast, Maligne Mountains on southwest. Maligne River gorge is cut in Palliser limestones.

4.6 (44.4) East—Roche Bonhomme (8,185 feet); a faulted, synclinally folded structure unit composed of pre-Devonian, Devonian and Banff formations.

4.9 (44.1) West—Gently dipping limestone strata of Palliser formation exposed in railway cut.

5.3 (43.7) Southeast—Excelsior Mountain (9,100 feet), prominent peak in Maligne Mountains composed of Lower Cambrian and/or Proterozoic clastics.

5.8 (43.2) East—Gorge in northwest termination of Roche Bonhomme cut in axial zone of syncline former in Devonian and Carboniferous strata. A small fault can be seen in cliff directly northeast of gorge; apparent vertical displacement is 500 feet.

6.2 (43.8) West—The Palisade: upper cliffs formed of Palliser formation; middle slope, of the shale facies of Fairholme formation; lower cliff, of pre-Devonian strata (Ordovician in part). East face of the Palisade is controlled by joints; western slope conforms to bedding planes of the Palliser formation. The Palisade, like Roche Bonhomme on the east side of Athabaska Valley, is located in foot wall block of Pyramid fault and forms westernmost Front Range at this latitude.

6.4 (42.6) West—Good view of Pyramid Mountain (9,076 feet) through gorge in Palisade. Pyramid Mountain is composed of red and orange-weathering Lower Cambrian quartzites and Proterozoic quartzites and argillites.

6.9 (42.1) West—Branch road to Palisade Motel and Lodge. This is the old Swift Ranch, near which Kindle (1929) obtained a Lower Ordovician ("Ozarkian") fauna from strata at base of the Palisade.

7.0 (42.0) East—Old lake terrace on east bank of the Athabaska River, approximately 300 feet above present river level.

7.4 (41.6) East—Branch road to Jasper Airport.

7.6 (41.4) Canadian National Railway underpass.

7.7 (41.3) Road cut in Pleistocene lacustrine sands.

8.1 (40.9) East—Gorge in west slopes of Colin Range cut by Garonne Creek in Devonian limestones. Mt. Colin on south side of gorge, Mt. Hawk on north side. These mountains, within a single structural unit, are separated from the structural unit of Roche Bonhomme by strike faults, East Chetamon fault, and West Chetamon fault.

8.5 (40.5) East—Branch road to Henry House ½ mile south on Canadian National Railway.

8.6 - 9.3 (39.7 - 40.4) West—Cliff at base of Palisade is composed of interbedded units of hard, light grey limestone and dolomite with edgewise conglomerate, and yellow-weathering, silty limestone and rare sandstone. Apparently over 1,500 feet of these beds are present, but only the upper 800 feet were alluded to as 'Ozarkian' by Kindle. This cliff is continuous with west peak of Chetamon Mountain.

10.0 (39.0) North—Three peaks in foreground are topographically within Chetamon Mt., however, east peak, composed of Carboniferous strata, is structurally continuous with Esplanade Mt.; medial peak consists of a fault block of

Devonian and Banff strata with West Chetamon fault at its base; west peak consists of a cliff of pre-Devonian strata with Palisade fault at its base.

10.2 (38.8) East—Mt. Hawk, peak in Palliser limestone, Carboniferous in receding ledges on west slopes.

10.7 (38.3) Bridge crossing Snaring River.

11.1 (37.9) East—Gorge cut by Morro Creek in Palliser limestones. Mt. Hawk on south side of gorge; Morro Peak on north side.

11.3 (37.7) West—Buttress Mountain (8,809 feet), visible through near, narrow gap in the Palisade, Snaring Mountain is visible through distant broad gap. Both mountains lie above Pyramid fault and are composed of Lower Cambrian and Proterozoic clastics. These mountains are structurally continuous with Pyramid and Maligne Mountains.

11.4 (37.6) West—Branch road to Moberly Flats and Celestine Lake. (This road junction is Mile 0.0 of road log 1D.)

11.6 (37.4) East—Morro Peak (5,504 feet), at northeast termination of Colin Range, is composed of gray-weathering limestones of Palliser formation with brown-weathering beds of Banff formation on west slopes.

12.4 (36.6) Canadian National Railway level crossing. North—Esplanade Mt. with easternmost peak formed in Palliser formation, next peak west in Upper Banff member. Rundle group and Rocky Mountain formation are exposed in adjacent peaks of east ridge of Chetamon Mt.

12.7 (36.3) North—Gargoyle Mt. on strike continuity with Esplanade Mt.; similar in physiographic-stratigraphic relationships.

12.8 (36.2) Strike continuity of light gray-weathering Palliser formation and subjacent yellow-weathering Alexo formation can be observed in Esplanade Mt. on northwest and Morro Peak on southeast.

12.9 - 13.0 (36.0 - 36.1) Bridge crossing Athabaska River. South—Athabaska Point on east bank of river is formed of Banff limestones. Banff-Rundle contact is exposed in west promentory.

13.0 - 32.0 (17.0 - 36.0) Highway built upon abandoned grade of Grank Trunk Pacific Railway. The Grand Trunk Pacific and Canadian Northern amalgamated in 1916 to form the Canadian National Railway. Selected portions of separate grades of the old railways were abandoned and subsequently used for Provincial Highway No. 16.

13.0 (36.0) South—Road outcrop at base of Morro Peak. Massive dark gray limestone in the lower part of Palliser formation. Note glacial polish and scour on rock spurs.

13.1 (35.9) South—Road outcrop directly above west end of pond, contact of dolomitic limestones of Palliser formation with silty limestones of Alexo formation.

13.2 (35.8) South—Mt. Hawk limestones exposed in ridge above east end of pond.

13.3 (35.7) South—Perdrix shales underlie forested saddle.

13.4 - 13.5 (35.5 - 35.6) South—Cold Sulphur Spring issues from upper, nodular beds of Flume formation. Exposures of Overlying interbeds of black shale and limestone are in base of Perdrix formation. Warren's (1932) type *Spirifer jasperensis* zone, abundantly fossiliferous, is in upper one foot of limestone directly below black shales. The nodular beds at the spring form Upper Flume member; the subjacent thick-bedded, light and dark gray limestone and dolomite with *Amphipora* and bulbous algae form Lower Flume member. The Devonian-pre-Devonian contact is placed arbitrarily at bedding plane approximately 20 feet above prominent dark brown glacial-scoured limestone beds which occur directly west of rock retaining wall. An analysis of waters of Cold Sulphur Spring would probably be similar to that recorded for spring waters at Mile 14.2 (34.8).

13.7 (35.3) South—Pre-Devonian strata of Cold Sulphur Ridge are faulted (Esplanade fault) upon a tight anticline in Rocky Mountain formation exposed on west side of wooded saddle above road. Axis of an adjacent syncline in Triassic Spray River strata coincides with notch in skyline.

14.0 - 14.1 (34.9 - 35.0) Road outcrop of Triassoc Spray River siltstone and shale exposed in common limb of a syncline on the west, an anticline on the east.

14.1 (34.9) South—Road outcrop of parts of Rocky Mountain formation.

14.2 (34.8) South—Sulphur spring floods small marsh below the road. A hypothetical combination of an analysis of the spring water by Mr. E. A. Thompson of the Department of Mines follows:

Sodium Chloride	452.0 p.p.m.
Potassium chloride	trace
Sodium sulphate	68.0
Magnesium sulphate	242.0
Calcium sulphate	69.0
Calcium bicarbonate	388.0
Silica	0.5
Iron and Aluminum Oxides	0.7
Hydrogen Sulphide	104.0
Carbonic acid	5.3
total p.p.m.	1,329.5

14.3 (34.7) South—Rundle group underlies forested slope on far side of marsh area, randon exposures in peak above.

14.3 - 14.4 (34.6 - 34.7) South — Agrillaceous limestones of Upper Banff Member are exposed on slopes 200 feet off the road; animal trail at west end of outcrop provides easy access.

14.4 (34.6) South—Lower Banff member underlies wooded saddle.

14.5 (34.5) South—Limestone ridge of Palliser formation located in axial zone of an anticline; southwest and northeast dips visible.
North—This same anticline can be seen in Grassy Ridge where an inverted U-shaped outcrop of Palliser is enveloped by a gulley formed in lower Banff.

14.6 (34.4) South—Banff and Rundle beds underlying forested slopes are in west limb of syncline.

14.8 (34.2) South—Cinquefoil Mt. (7,412 feet), on east limb of syncline is composed of Devonian, Carboniferous and Triassic strata.

14.9 (34.1) South—Jacques Creek flows via numerous distributaries through muskeg area.

15.2 (33.8) Approximately on strike with synclinal axis. Triassic and possibly Jurassic sediments in axial zone underlie muskeg.

15.6 (33.4) South—Red-weathering Triassic Spray River siltstones and cherty limestone of Rocky Mountain formation are exposed on west slopes of Cinquefoil Mt. at northwest termination of Jacques Range.

15.7 (33.3) South—Contact of dark Rocky Mountain formation and light Rundle group visible on north spur of Cinquefoil Mt.

15.7 - 16.0 (33.0 - 33.3) Randon outcrops of Carboniferous strata exposed on forested slopes above road.

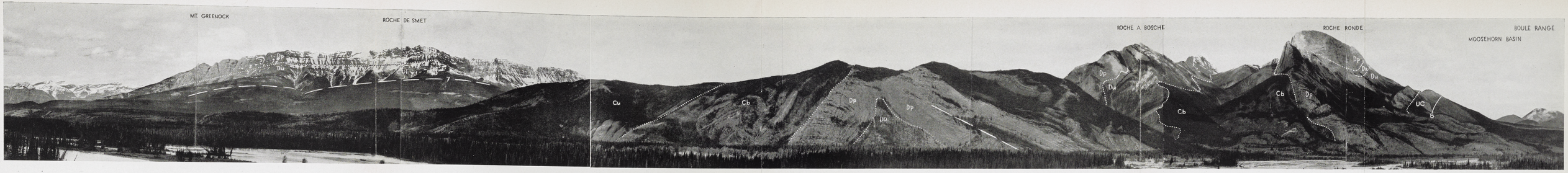
16.0 (33.0) South—Contact of Banff and Palliser formations exposed directly east of small gulley. Lower and Upper Banff members are exposed in peak above.

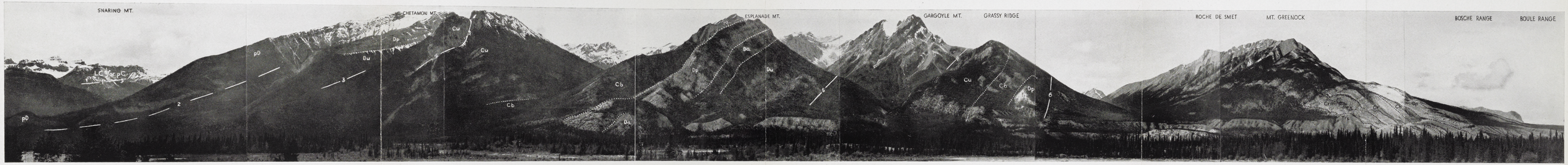
16.1 (32.9) South—Edna Lake; North—Jasper Lake; these lakes together with Talbot Lake and Brule Lake were once part of an extensive lake which flooded the Athabaska River in late Pleistocene. This Pleistocene Lake is alluded to as Miette Lake by Kindle (1929). Portions of the Pleistocene lake terrace can be observed approximately 350 feet above present water level on either side of Athabaska Valley, indicating a marked lowering of the drainage outlet on the east margin of park.

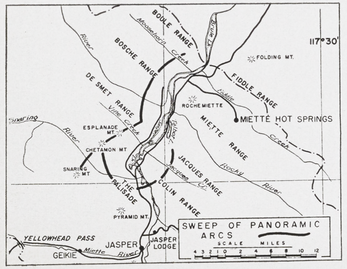
16.2 (32.8) North—Jasper Lake; four miles long and one mile wide, is mostly very shallow and silted up. Wind blown sand bars cut off Edna Lake, the upper of the Fish Lakes.

16.4 (32.6) Crossing approximate surface position of Jacques fault; Cinquefoil Mt. in the hanging wall block, succeeding fault block of Triassic and Carboniferous strata in foot wall.

16.6 (32.4) North—Mt. Greenock (6,881 feet), of De Smet Range, on the north bank of Athabaska River, is in strike continuity with Cinequfoil Mt. of Jacques Range on south bank; physiography, stratigraphy and structure of each range are similar. Devonian strata at base of either range are thrust upon red-weathering Triassic siltstone; approximate position of the fault contact on east slopes of either range can be observed from road. See Plate 4.)

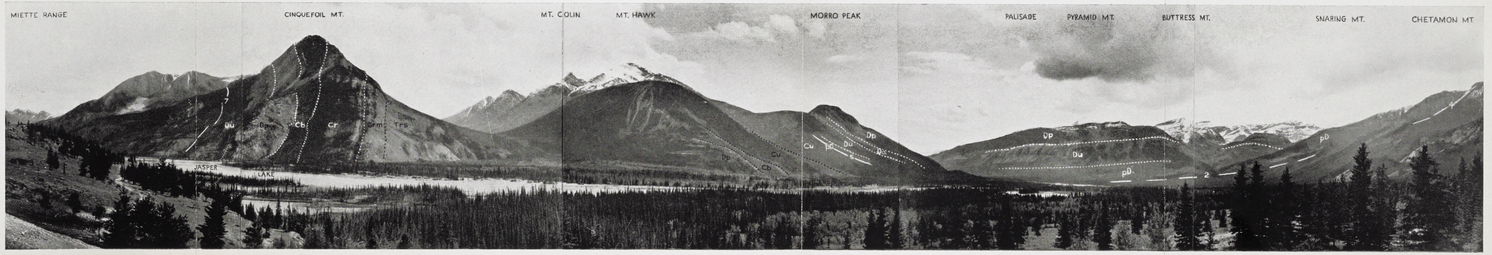






Panorama of Rocky Mountain Front Ranges, Athabasca River. Spray River (Trs), Rocky Mountain (Crm), Rundle (Cr), Banff (Cb), Carboniferous undivided or partially undivided (Cu), Palliser (Dp), Alexo (Da), Devonian undivided or partially undivided (Du), pre-Devonian (pD), Upper Cambrian (UC), pre-Cambrian (pC), Pyramid fault (1), Palisade fault (2), West Chetamon fault (3), East Chetamon fault (4), Espanade fault (5), Grassy Ridge fault (6), Jacques fault (7), Miette fault (8). Geologic annotation approximate only.

Photographs by A. H. Ellison.



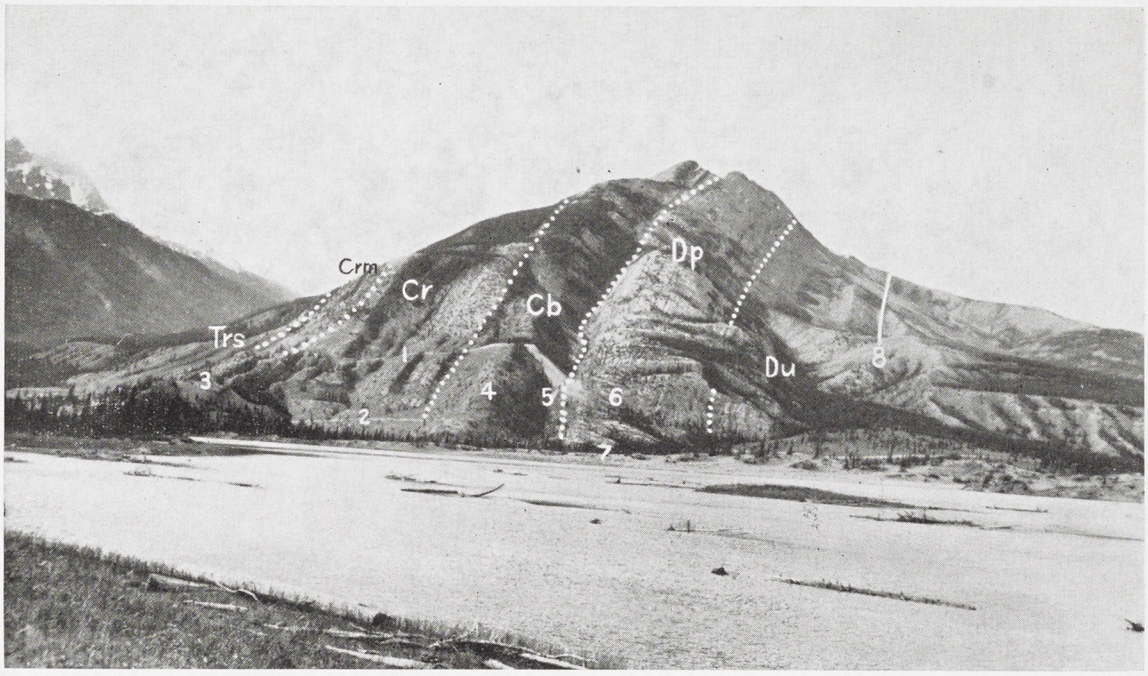


Plate IV

Mt. Greenock. Looking northward across Jasper Lake. Spray River (Trs), Rocky Mountain (Crm), Rundle (Cr), Banff (Cb), Palliser (Dp), Alexo (Da), Devonian partially undivided (Du), Trans Mountain Pipeline right-of-way (1), Celestine Lake road (2), Snaring Ridge (3), Windy Ridge (4), "Spirifer" gulley (5), "Spirifer" Ridge (6), Canadian National Railway (7), Jacques fault (8).

16.9 - 17.0 (32.0 - 32.1)	South—Road outcrop and Triassic Spray River siltstone exposed in common limb of a tight syncline on the west and an anticline on the east.
17.0 (32.0)	Wind-drifted sands at roadside, sands held firm by vegetation.
17.2 - 17.4 (31.6 - 31.8)	South—Road outcrop of Rocky Mountain formation and fossiliferous Upper Rundle strata located on west limb of anticline.
17.4 (31.6)	Approximately on strike with axis of anticline. Banff exposed in axial zone on forested slopes directly south, random outcrops of beds in east flank are exposed in forested ridge above lake.
17.5 (31.5)	North—Complex succession of several small structures can be seen on north bank of Athabaska River.
17.6 - 20.6 (N.A.)	Road built upon wind-drifted sand bar which separates Jasper Park on the north from Talbot Lake on the south.
18.3 (30.7)	South—Branch road to picnic area on Talbot Lake.
19.2 (29.8)	South—Forested, rounded crest of Makwa Ridge, visible in distance in Rocky River valley, is apparently formed of anticlinally folder Triassic and Carboniferous strata.

19.4 (29.6)	East—West slopes of Miette Range, first range of Rocky Mountain Front Ranges sub-province. Bosche Range on north side of Athabaska valley is structurally continuous with Miette Range.
19.8 (29.2)	North—Roche a Bosche (6,966 feet), and Roche Ronde (7,014 feet), at south termination of Bosche Range.
21.3 (27.7)	South—Muskeg valley of Rocky River is apparently underlain by Triassic and Jurassic strata. This valley is physiographically and probably structurally similar to Snake Indian River valley on north side of Athabaska River.
21.6 (27.4)	North—Monument at roadside is near second site of Jasper House, Northwest Company Trading Post (1826 to 1884).
21.8 (27.2)	Bridge crossing channel of Rocky River.
22.0 (27.0)	North—Structure profile of west part of Roche a Bosche.
23.1 (25.9)	Bridge crossing channel of Rocky River.
23.2 (25.8)	Bridge crossing channel of Rocky River. Vertical strata exposed in river bank are in Banff formation.
23.2 - 23.6 (25.4 - 25.8)	South — Road outcrop of banded argillaceous limestone of Upper Banff member exposed in overturned west limb of anticline.
23.4 (25.6)	South—Vegetation-covered saddle underlain by basal shale unit of Banff formation; uppermost Palliser beds form vertical limestone face.
23.5 - 23.7 (25.3 - 25.5)	South—Road outcrop of dark gray and dark brown limestones with bands of dolomitic tracery are in Palliser formation; ten feet of silty limestone and siltstone of Alexo formation are exposed at base. Beds in this outcrop are vertical to overturned on west limb of large anticline.
23.7 (25.3)	North—Structure profile of Roche a Bosche.
23.9 (25.1)	South—Disaster Point Alpine Hut erected in small clearing.
24.3 (24.7)	South—Outcrop of Perdrix black shales dipping southwest. Small quarry and discarded lime of former small lime plant near fault contact of Perdrix and Mt. Hawk formations.
24.4 (24.6)	North—Sharp anticline formed in Palliser beds in Roche a Bosche is on strike with faulted anticline in Roche Miette; drop in elevation of formation contacts on the north side of the river is indicative of local north plunge on the structure.
24.5 (24.5)	South—Road outcrop of poorly fossiliferous Mt. Hawk limestone in near-vertical east limb of anticline. Fault in Palliser formation can be seen at the location where vertical and horizontal strata abutt.

24.6 (24.4) South—Termination of road outcrop in Upper Banff member located on common limb of anticline on the west and tight faulted syncline on the east.

24.8 (24.2) South—Cliff of Palliser limestone, contact with superjacent Banff formation in notch above.

24.9 (24.1) Crossing Trans Mountain Pipeline right-of-way.

25.1 (23.9) Northeast—Bedson Ridge, on west flank of Boule Range, is westermost Paleozoic inlier of Foothills sub-province. Bedson Ridge forms east margin of Moosehorn Basin which is in the foot wall of easternmost Front Ranges fault (McConnell fault zone).

25.2 (23.8) South—Roche Miette (7,599 feet), north terminus of Miette Range. Cliff in peak of massive Palliser limestone, banded limestone skirt in Alexo and Mt. Hawk formations, deformed dark shales in Perdrix formation. Limestones directly above red-weathering zone on east slopes are Flume formation, red-weathering beds are Ghost River equivalents, underlying beds are uppermost Upper Cambrian.

26.0 (23.0) Approximate surface position of Miette fault (McConnell fault zone).

26.8 (22.2) North—Moosehorn Basin in strike valley of Moosehorn Creek on north side of Athabaska River.

26.9 (22.1) South—Slack pile of abandoned Jasper Colliery. Seams mined are in basal part of Lower Cretaceous Luscar formation located directly in foot wall of McConnell fault zone.

27.0 (22.0) Pocahontas Warden Headquarters.

27.1 (21.9) Crossing Trans Mountain Pipeline right-of-way.

27.2 (21.8) South—Branch road to Punchbowl Falls, Fiddle Creek and Miette Hot Springs (Road junction is Mile 0.0 of road log 1E).

28.0 (21.0) South—Pocahontas Basin; North—Moosehorn Basin; these basins, like the Mountain Park Basin and Bighorn Basin, all of which are in strike alignment, occur in foot wall block of McConnell fault zone and are the succeeding synclines of the westernmost Paleozoic inliers of Foothills subprovince (Boule, Fiddle, Nikanassin and Bighorn Ranges). These basins are underlain by complexly deformed Cretaceous, Jurassic and Triassic rocks. Roadside exposures of Luscar, Cadomin, Nikanassin, Fernie and Spray River formations may be observed on route of road log 1E within Pocahontas Basin.

28.4 (20.6) Northeast—Bedson Ridge.

29.0 (20.0) South—North termination of Ashlar Ridge. Directly west of Fiddle Range, this ridge is composed of anticlinally folded Carboniferous and Devonian strata.

29.2 (19.8) South—Cliff of Palliser limestone dipping almost vertically in west flank of Ashlar Ridge structure.

30.8 (18.2) Bridge crossing Fiddle River; one-half mile south from bridge the river cuts transversely through Ashlar Ridge. Perdrix shales exposed in west bank or river, Flume limestones in east bank.

30.9 (18.1) North—Gravel bench provides excellent viewpoint to observe structure on profile of Boule Roche on north bank of Athabaska River.

31.3 (17.7) South—Roche a Perdrix (7,002 feet), at northwest termination of Fiddle Range, westernmost Paleozoic inlier of Foothills sub-province in hanging wall block of Boule-Nikanassin fault.

31.4 (17.6) South—Palliser limestone on west limb of Roche a Perdrix anticline, tight syncline in peak.

31.8 (17.2) South—Perdrix shales in axial zone of tight anticline, Flume and possibly Cambrian limestones in core.

31.9 (17.1) North—Good view of Boule Roche, scarp of Devonian limestones thrust over Lower Cretaceous Nikanassin sandstones.

NOTE: Currently the road from mile 32 to Hinton is being relocated, hence pertinent portions of this log will require early modification.

32.2 (16.8) East gate, Jasper National Park.

32.6 (16.4) Bridge.

32.8 (16.2) Bridge crossing Drystone Creek.

33.0 (16.0) South—West slopes of Folding Mountain.

34.6 (14.4) South—Road outcrops of Spray River siltstone and Rundle limestone on west limb of Folding Mountain anticline.

34.7 (14.3) South—Road outcrop of Spray River siltstone overlying white-weathering, light gray, cherty limestone of uppermost Rundle group. A small fault is inferred to separate this outcrop from that at mile 34.6, (14.4).

34.9 (14.1) Crossing axis of Folding Mountain anticline, Rundle beds in axial zone, plunge of the fold is southeast, culmination is north of the highway. Dowling and others have suggested that the drop in altitude of beds of this structure on the north side of the Athabaska indicates either a rapid north plunge of the fold or a tranverse break across regional strike of the foothills.

35.5 (13.5) North—Road outcrop of Nikanassin sandstone.

38.6 (10.4) South—Cap Ridge formed of resistant Upper Cretaceous sandstones of Solomon member and Brazeau formation which overlie Wapiabi shales. These strata are in common limb of anticline on the west, and syncline on the east.

38.3 (10.7)	Bridge.
39.4 (9.6)	Crossing axis of Seabolt syncline, Brazeau sandstone in trough.
40.6 (8.4)	North—Road outcrop of Brazeau sandstone.
40.7 (8.3)	Crossing axis of Seabolt anticline, crest is in strike ridge directly south. Twin knobs on ridge are held up by Solomon sandstone repeated in successive fault slices.
41.6 (7.4)	North—Brazeau beds in near ridges are vertical to overturned on east flank of Seabolt anticline.
41.8 - 43.1 (5.9 - 7.2)	North—Road outcrop of scattered exposures of Brazeau strata dipping 60 to 80 degrees northeast in common limb of Seabolt anticline on the west, Entrance syncline on the east.
43.5 (5.5)	South—Bar F. Ranch.
44.3 (4.7)	Crossing Trans Mountain Pipeline, approximately on axis of Entrance syncline. Paskapoo-Edmonton beds in axial zone hold up perched syncline on High Divide Ridge directly southeast.
44.7 (4.3)	North—Branch road to Entrance.
45.1 (3.9)	Bridge crossing Maskuta (Prairie) Creek.
45.5 (3.5)	Bridge.
45.9 (3.1)	Bridge.
46.5 (2.5)	Approximate position of axis of Prairie Creek anticline commonly regarded as eastermost foothills structure at this latitude.
47.0 (2.0)	East—Ridges of Paskapoo formation in distance are on west flank of Alberta syncline of Plains region.
48.2 (0.8)	Bridge crossing Happy Creek, Brazeau strata with thin carbonaceous seams exposed in banks.
49.0 (0.0)	Hinton Hotel and Canadian National Railway Station.

ROAD LOG 1B — JASPER TO YELLOWHEAD PASS

SUMMARY

This east-west route parallels the trend of major folds which are transverse to the common northwest regional strike of the Rocky Mountain Main Ranges. Roadside exposures of arkosic sandstones and quartzites, fine pebble conglomerate, green and some

purple argillites, are abundant. The age of these is probably Proterozoic, possibly in part Lower Cambrian. Whereas the attitude and cleavage of strata in the outcrops indicate many complex folds, most indicate that the strata are located on the common limb of an anticline on the north side of the route, a syncline on the south side.

0.0 (17.9) Canadian National Railway crossing at southwest outskirts of Jasper. The branch road, located only a few hundred feet south of the railway crossing, leads west to Yellowhead Pass and Tete Jaune.

0.1 (17.8) Hayward Lumber Company.

0.3 (17.6) North—Canadian National Railway. Previous to 1924, two railways, the Grand Trunk Pacific and Canadian Northern traversed the Athabaska, Miette and Fraser valleys. After amalgamation to form the federal-owned Canadian National Railway, only selected parts of old grades were retained for Canadian National use; abandoned parts are now occupied by the road.

1.0 (16.9) South—The Whistlers (8,085 feet), formed of Lower Cambrian and/or Proterozoic quartzites and argillites. Rocks exposed along route are of Lower Cambrian and/or Proterzoic ages—this allusion of age is implied to all succeeding comments on road outcrop.

1.2 (16.7) North—Railway outcrop of red sandstone, strike S. 45° E., dip 75° S.W.

1.5 (16.4) Road outcrop of interbedded dull green and red shales and green-gray sandstone with pebble bands; strike S. 70° E., dip 80° S.; cleavage dips 55° S.W.; beds overturned.

1.7 - 1.8 (16.1 - 16.2) Road outcrop of massive quartzite and argillites, strike S. 80° E., dip 85° S.

2.0 - 2.1 (15.8 - 15.9) Road outcrop of extensively cleaved argillite in contact with ripple-marked, massive, gray-green sandstone and pebble conglomerate strike S. 75° E., dip 53° S. Cleavage vertical. Common limb, syncline on the south, anticline on the north.

2.2 - 2.3 (15.6 - 15.7) Road on strike, bedding planes exposed.

2.4 (15.5) South—Indian Ridge, cirque wall between The Whistlers and Muhigan Mountain.

2.7 (15.2) North—Trail to Caledonia Lake.

2.8 (15.1) Glacial boulder till deposited by former east-moving Miette valley glacier.

2.9 (15.0) North—Caledonia Creek.

3.0 (14.9) Bridge.

3.2 (14.7) Crossing Trans Mountain Oil Pipeline right-of-way.

3.2 (14.7)	Bridge crossing Miette River.
4.2 (13.7)	South—Road outcrop of massive quartzites.
4.6 (13.3)	Road outcrop of massive quartzite, strike N. 70° E., dip 40° S.
4.9 - 5.0 (12.9 - 13.0)	North—Road outcrop of massive quartzite, strike S. 85° E., dip vertical.
5.0 (12.9)	South—Road outcrop of cleaved and contorted argillites. Strike S. 55° E., dip 60° N.E., cleavage dip 35° S.W.
5.1 (12.8)	North—Three peaks in mountain wall are named successively east to west, Mt. Cairngorm (8,564 feet); Mt. Henry (8,626 feet); Emigrants Mt. (8,376 feet).
5.2 - 5.3 (12.6 - 12.7)	Road outcrop of cleaved argillites.
5.3 (12.6)	Bridge crossing Conifer Creek.
5.6 - 5.8 (12.1 - 12.3)	South—Road outcrop of quartzites and cleaved argillites, strike S. 60° E., dip 42° S.W., cleavage 60° S.W.
5.9 - 6.0 (11.9 - 12.0)	Bridge. Glacial scour notable on hogsbacks.
6.1 - 6.2 (11.7 - 11.8)	South—Road outcrop of massive quartzite and argillite. Strike S. 55° E., dip 55° S.W., cleavage dips approximately 75° S.W.
6.3 - 6.6 (11.3 - 11.6)	South—Road outcrop of quartzites with thin shale bands.
7.1 (10.8)	South—Ripple-marked, massive quartzite strike S. 60° E., dip 70° S.W.
7.4 - 8.0 (9.9 - 10.5)	Scattered road outcrops of quartzites and argillites, variable strikes and dips.
8.1 (9.8)	Bridge crossing Meadow Creek.
8.2 (9.7)	Crossing Trans Mountail Oil Pipeline right-of-way.
8.3 (9.6)	Railway level crossing.
8.7 (9.2)	South—Branch road to Geikie, railroad whistle stop. Bridge crossing Miette River.
8.8 - 10.0 (7.9 - 9.1)	Scattered road outcrops of massive quartzites and argillites, strike S. 40° E., dip 60° S.W.
10.3 (7.6)	South—Roche Noire (9,594 feet), formed of Lower Cambrian and/or Proterozoic quartzites and argillites.

10.5 - 10.6 (7.3 - 7.4) Purple and green argillite; colour contact sharp.

11.6 (6.3) West—Good view of Yellowhead Mt. and adjacent peaks in the continental divide. McEvoy (1900) reports, "above the highest part of the—conglomerates seen in Yellowhead Mountain, no exposures were seen for a height of 1,400 feet. There is then exposed 200 feet of flat-lying beds of rusty-weathering, light gray crystalline dolomite, overlain by 1,400 feet of light gray crystalline dolomite, overlain again by 1,400 feet of gray quartzites to the top of the mountain." The light-coloured band located in middle part of Yellowhead Mt. is probably the medial carbonate unit. It is apparently equivalent to Lower Cambrian Mural limestone formation of Mt. Robson, superjacent quartzite unit represents the Mahto sandstones; upper part of subjacent quartzite unit, the McNaughton sandstones (see Plate 5).

12.1 (5.8) Crossing Trans Mountain Pipeline right-of-way.

12.3 - 12.7 (5.2 - 5.6) Road outcrop of massive quartzite and argillite, strike S. 70° E., dip 35° S.

12.7 (5.2) Glacial boulder till.

14.3 (3.1) Bridge crossing Dominion Creek. (Derr Creek.)

14.8 (3.1) South—Yellowhead District Warden Headquarters.

15.6 (2.3) Road outcrop of soft, badly weathered shales extremely contorted; possibly in fault zone. Rapid changes of bedding attitude along exposure.

15.9 (2.0) Crossing Trans Mountain Oil Pipeline right-of-way.

16.1 - 17.1 (0.8 - 1.8) Road outcrop of contorted massive sandstone and argillite.

17.6 (0.3) Bridge crossing Miette River. Concrete pier of abandoned railway bridge directly northwest.

17.8 (0.1) Crossing Trans Mountain Oil Pipeline. Black shale outcrop visible across valley.

17.9 (0.0) Summit of Yellowhead Pass (elevation 3,711 feet). This pass is one of the lowest passes across the Rockies on the continent. The summit defines the drainage divide of Miette River flowing east, and Fraser River drainage flowing west. It is the west boundary of Jasper National Park and of Alberta. The road continues on to Tete Jaune in the Rocky Mountain Trench and en route provides access to Mt. Robson. Walcott (1913 and 1928) indicates the Yellowhead Pass vicinity to be type locality of his Proterozoic Miette formation which is stated to be composed of over 2,000 feet of massively bedded, more or less dirty-gray sandstones with thick bands of gray and greenish siliceous shales.

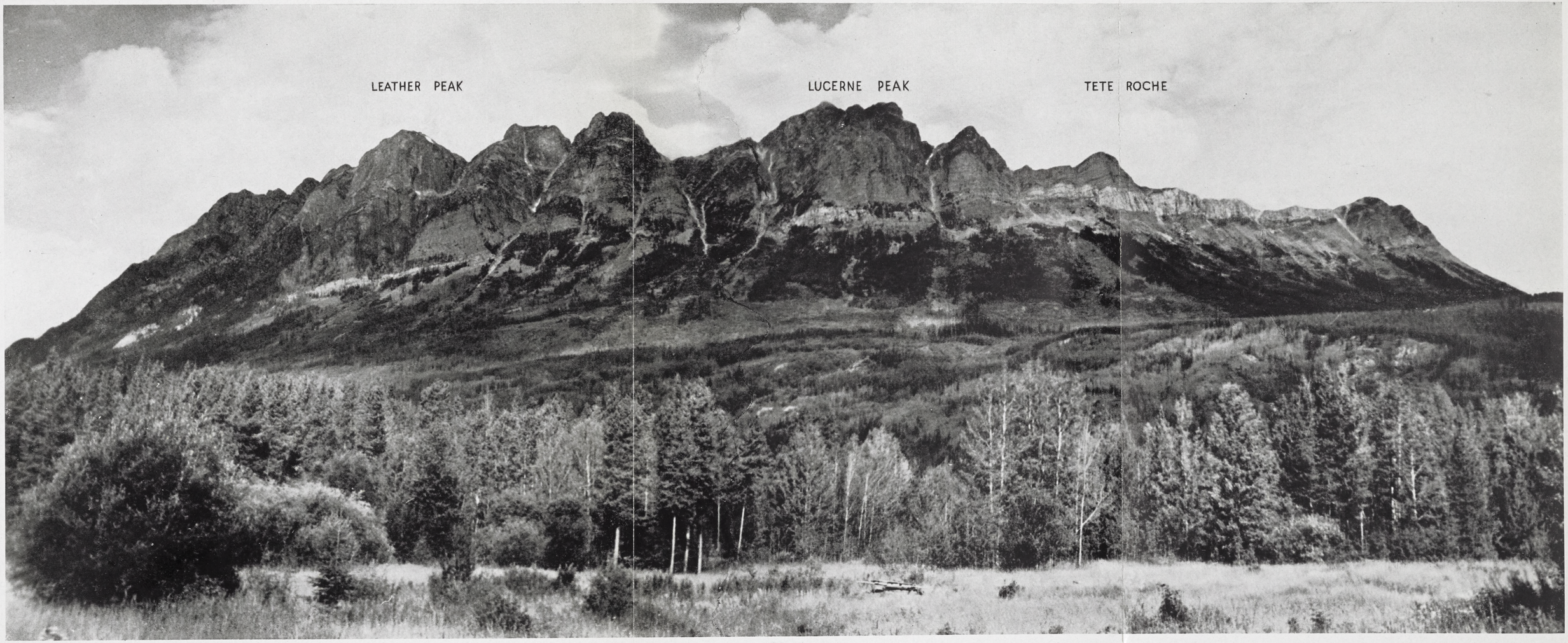


PLATE V

YELLOWHEAD MOUNTAIN—Looking northwest from Yellowhead Pass Route. See description road log 1A, mile 11.6 (6.3).

Photography by M. K. Sorensen

ROAD LOG 1C — JUNCTION, HIGHWAY NO. 16, TO MEDICINE LAKE

SUMMARY

The route trends southeast along the strike valley of the tributary Maligne River. Colin Range, the westernmost Front Range, is located east of the route; Maligne Mountains, the easternmost Main Range, is located west of the route. Pyramid fault (Castle Mountain fault zone) is located in the forested slopes of Maligne Mountains. A spectacular gorge at mile 5.7, (9.1), cut in Palliser limestone, illustrates clearly the geomorphic process of headward erosion of steep-graded mountain rivers. Outcrops along the route are poor and expose only upper Palliser and lower Banff strata.

0.0 (14.8)	Junction of Highway No. 16 and branch road to Fish Hatchery, Jasper Lodge, Maligne Canyon and Medicine Lake.
0.1 (14.7)	Bridge crossing Athabaska River.
0.2 (14.6)	North—Branch road to Fish Hatchery.
0.9 (13.9)	South—Branch road to Jasper Lodge.
1.2 (13.6)	South—Annette Lake.
1.6 (13.2)	North—Edith Lake.
2.3 (12.5)	North—Branch road, Edith Lake circular drive.
3.0 (11.8)	North—Branch road to lower part of Maligne Canyon.
3.4 - 4.2 (10.6 - 11.4)	Road outcrop of poor exposures of Banff limestone.
4.6 (10.2)	North—Excellent view of Pyramid Mt. on north side of Athabaska River valley. Pyramid Mt., like the Maligne Mountains directly west of our route, is composed of Lower Cambrian and/or Proterozoic quartzites and argillites. These mountains are located directly in the hanging wall of Pyramid fault (Castle Mt. fault zone). They form the easternmost range of Main Ranges sub-province.
5.4 (9.4)	East—View of Maligne Canyon. Thin limestones of Banff formation in upper part of gorge.
5.5 (9.3)	Viewpoint—Canyon cut in massive gray limestones of Palliser formation.
5.6 (9.2)	Northeast—Roche Bonhomme, composed of Carboniferous and Devonian strata.
5.7 (9.1)	Bridge crossing Maligne River. Channel on south is on bedding planes of Palliser limestone. From this point, Maligne River descends almost 500 feet in less than one mile. The canyon, which in places is 200 feet deep with adjacent walls only a few feet apart, may be viewed from the fenced-

off area directly northeast of bridge. The canyon is cut along joint planes in Palliser formation. Partly obliterated pot holes within the walls of the canyon indicate plainly the process by which the canyon has been carved. The canyon is the result of headward erosion of the waterfall which spilled over wall of Palliser limestone cliffs on Athabaska River.

5.9 (8.9) East—Road outcrop of Banff formation.

6.5 (8.3) Roadside exposures of glacial boulder till. Maligne valley has been deepened and widened to U-shaped cross-section by a large valley glacier.

7.7 - 8.4 (6.4 - 7.1) Road outcrop of Palliser limestone.

8.6 (6.2) Bridge crossing Two Valley Creek. Gorge cut in Palliser limestones.

9.1 (5.7) South—Excelsior Mt. (9,100 feet).

11.5 (3.3) North—Basal Banff shales exposed in road materials pit.

12.0 (2.8) North—Anticline of Palliser limestone in Colin Range. This range, westernmost Front Range at this latitude, occurs in foot wall of Pyramid fault.

14.5 (0.3) South—Landslide talus, Maligne River flows underground for about ½ mile.

14.8 (0.0) Northwest end of Medicine Lake. At the boathouse you can board a motor launch for a five mile cruise to the upper part of the lake. There cars will take one on a 12-mile trip through virgin forest along Maligne River to the north shore of Maligne Lake.

ROAD LOG 1D — JUNCTION, HIGHWAY NO. 16, TO MT. GREENOCK

SUMMARY

The route parallels the north bank of the Athabaska River and traverses the western Front Ranges. It provides access to geologic sections which are the strike continuations of those exposed on the route of road log 1A. On spurs of Mt. Greenock at the east end of the route, the transverse cuts of the right-of-ways of the Trans Mountain Pipeline, Celestine Lake road and Canadian National Railroad, each provide easy access to excellent exposed sections of the Carboniferous and Devonian formations.

0.0 (6.1) Junction of Highway No. 16 and branch road to Moberly Flat, Mt. Greenock and Celestine Lake. (This junction is mile 11.4 of road log 1A.) Southwest—Palisade with thin beds of Banff formation in crest, Palliser and Alexo in upper cliff, Mt. Hawk and Perdrix in partly tree-covered, upper slope, Flume and pre-Devonian in second cliff. The upper part of this stratigraphic sequence is exhibited, on strike northward, in basal slope of Snaring Mountains; the lower part, on strike northward, in west peak of Mt. Chetamon.

0.4 (5.7) West—Buttress Mountain visible through gap in the Palisade. Buttress Mountain, on north strike from Mt. Pyramid, is composed of Lower Cambrian and Proterozoic quartzites in fault contact with Carboniferous of the Palisade.

1.4 (4.7) North—Three peaks in foreground are topographically within Chetamon Mt. However, east peak is in structural continuity with Esplanade Mountain and is composed of Carboniferous strata; medial peak is composed of a fault slice of Devonian strata; the west peak is composed of pre-Devonian beds continuous with those in the Palisade. Faults are located at base of east slopes of the west and medial peaks.

Southeast—View of Morro Peak on south side of Athabaska River. Rounded ridge is formed of Palliser limestones; directly west of ridge the Lower Banff member is located in a saddle on west slopes of Mt. Hawk; Upper Banff member occurs in the adjacent small cliff; Rundle strata underlie forested back slope.

1.8 4.3 Gravel alluvium of intermittent stream.

2.7 (3.4) Bridge crossing small creek.

2.9 (3.2) Culvert.

3.3 (2.8) North—Two peaks in foreground of Esplanade Mountain. Devonian sequence in east peak, Banff sequence in west peak with Rundle exposed on transverse ridge on west slopes. Cobblestone Creek separates Carboniferous exposures of Esplanade Mt. from Carboniferous exposures on east peak of Chetamon Mt. Strata exposed in Esplanade Mt. are in structural continuity with those exposed on Morro Peak on south side of Athabaska valley.

3.6 (2.5) Large meadows, abandoned log cabin in southwest corner. North—Strike valley of Corral Creek. Devonian spur of Esplanade Mt. on west side; Gargoyle Mt. at head of valley in background is in strike continuity with Esplanade Mt.; Grassy Ridge, on east side of valley, rounded and tree-covered, is composed of Carboniferous and Devonian strata.

3.7 (2.4) Crossing Trans Mountain Oil Pipeline right-of-way.

3.8 (2.3) Bridge crossing Corral Creek.

3.9 (2.2) North—Branch roads to Warden's Headquarters. Large meadow known locally as Moberly Flats. Good view of Devonian sequence in Esplanade Mt. directly behind Warden's building. Yellow-weathering unit at base of cliff is composed of silty limestones and siltstones of Alexo formation.

4.0 (2.1) North—High terrace of late Pleistocene lacustrine sediments.

4.1 (2.0) Crossing Trans Mountain Oil Pipeline right-of-way.

4.2 (1.9) North—Good view of Gargoyle Mt., in strike continuity with Esplanade Mt.; similar in physiographic-stratigraphic relationships.

4.8 (1.3) Gravel alluvium and ford of Corral Creek. Tree-covered, rounded slopes of Grassy Ridge visible directly north.

5.0 (1.1) Bridge crossing Spring Creek.

5.1 (1.0) South—Roadside picnic table and fireplace.

5.2 (0.9) South—Extensive beaver dam ponding creek water directly below.

5.4 (0.7) Crossing Trans Mountain Oil Pipeline right-of-way.

5.7 (0.4) Bridge crossing Vine Creek. This creek drains strike valley between fault blocks of Grassy Ridge on the west and De Smet Range on the east. Valley underlain by Triassic.

5.8 (0.3) South—Branch road to Snaring Station one mile south on Canadian National Railway.

6.1 (0.0) Crossing Trans Mountain Oil Pipeline right-of-way. Hazardous single lane traffic beyond this point for cars and light trucks only. Large area for parking on meadow on south side of road. On the spurs of Mt. Greenock there is exposed a fine section of lowermost Spray River, Rocky Mt., Rundle, Banff, Palliser and Alexo formations. These are examined best by walking eastward from parking area at mile 6.1 along the pipeline right-of-way over Snaring and Windy Ridges, down 'Spirifer gulley' and around south-east base of 'Spirifer Ridge.' The return trip can be made via the road which traverses the several ridges parallel to and 1,500 feet south of the pipeline route. (See Plate 4.)

ROAD LOG 1E — JUNCTION, HIGHWAY NO. 16, TO MIETTE HOT SPRINGS

SUMMARY

The route obliquely traverses parallel bands of Lower Cretaceous, Jurassic and Triassic strata in the Pocahontas Basin. A Paleozoic inlier of the Foothills sub-province, Fiddle Range, forms the northeast margin of the basin; the Miette Range of the Front Ranges sub-province forms the southwest margin. The basin narrows towards, and terminates southeast of the Miette Hot Springs where the Miette Range is thrust directly upon the Foothills Paleozoic inliers, the Fiddle and Nikanassin Ranges.

0.0 (10.9) Junction. Branch road to Miette Hot Springs and Highway No. 16. (This junction is mile 27.2 of road log 1A).

0.1 (10.8) East—Concrete foundation of building of abandoned Jasper Park Collieries. Coal was removed (1910-1923) from a nine foot seam located in the Luscar formation 520 feet above Cadomin conglomerate.

0.2 (10.7) Bridge crossing Mountain Creek.

0.6 (10.3) West—Roche Miette (7,599 feet), composed of Upper Cambrian and Devonian strata in hanging wall block of the Miette fault (McConnell fault zone).

0.7 (10.2) East—Road exposures of sorted, fluvial-glacial gravels. The preponderance of Lower Cambrian quartzite pebbles and boulders in this till, which must have been derived from the mountains of Main Ranges sub-province, indicates that the Alpine valley glacier was exceedingly thick and moved over the ridges considerably above our present elevation. Kindle (1929) has reported finding metamorphic rocks on slopes of Roche Miette; these apparently were transported by ice from vicinity of Tete Jaune.

0.8 (10.1) West—Punchbowl Falls. Mountain Creek drops over steep west-dipping rib of Cadomin conglomerate, erosive action in superjacent basal beds of Luscar formation has hollowed out a basin or 'bowl' at foot of falls. Carbonaceous shales and sandstones of Luscar formation, exposed in ridge, are accessible by way of foot-bridge.

1.8 - 4.6 (6.3 - 9.1) Scattered roadside outcrop of carbonaceous shales and brown-weathering, fine-grained sandstones of Nikanassin formation. Upper part of Nikanassin formation contains several thin coal seams, one seam being four feet thick.

5.3 (5.6) East—West limb of Ashlar Ridge anticline; scarp is formed in nearly vertical Palliser limestones, brown-weathering Banff strata and gray Rundle strata in sawtooth ridges on back slope.

5.4 (5.5) East—Viewpoint, Triassic beds in Fiddle River gorge below dip steeply on west flank of Ashlar Ridge anticline. Superjacent shales of Jurassic Fernie formation occur in tree-covered ridge on west side of gorge. Red colour of clay underfoot is due to weathered material of ferruginous Triassic sequence.

5.5 - 5.6 (5.3 - 5.4) Road outcrop of shales and sandstones of the basal Nikanassin formation.

5.7 - 5.9 (5.0 - 5.2) South—Jurassic Fernie group exposed in creek.

5.9 (5.0) Bridge crossing Morris Creek. Road outcrop of carbonates of Triassic Whitehorse formation.

6.0 - 6.8 (4.1 - 4.9) Road outcrop of Triassic siltstone of Spray River formation.

7.0 (3.9) Culvert of Villeneuve Creek.

7.1 (3.8) Road outcrop of basal Middle Jurassic sandstone (Bajocian Rock Creek member equivalent); Triassic, Whitehorse formation exposed in slopes below roadside.

7.4 - 8.3 (2.6 - 3.5) Scattered road outcrop of Nikanassin sandstones and shales; sequence well exposed in creek above road at mile 7.6 (3.3). Fernie group exposed in Fiddle Creek at mile 8.2 (2.7).

9.1 (1.8) East—Fiddle Range visible through gap cut by Fiddle River transversely through Ashlar Ridge. The Fiddle River rises at the divide between Pocahontas and Mountain Park Basins. In its northward course the river cuts through Paleozoic limestones of Ashlar Ridge twice.

9.3 (1.6) Bridge crossing Sulphur Creek. Confluence of Sulphur Creek and Fiddle River is one-quarter mile downstream. Triassic Spray River siltstone exposed at approaches to bridge.

10.7 (0.2) Road outcrop, massive limestones, possibly Upper Cambrian, located directly in hanging wall of Miette fault of McConnell fault zone.

10.8 (0.1) Bridge crossing Sulphur Creek.

10.9 (0.0) Miette Hot Springs Pool. The springs, with different temperatures up to 120° F., issue approximately 1,000 feet south of the pool, from limestone near the axial zone of a faulted anticline. Calcium and magnesium sulphate form the major part of the dissolved solids being respectively 22.68 and 77.28 grains per gallon.

ROAD LOG 2 — HIGHWAY NO. 1A, JASPER TO BANFF

SUMMARY

The route between Jasper and Banff is mainly along regional strike upon a single fault sheet, that of the Castle Mountain thrust within the eastern sector of the Rocky Mountains Main Ranges sub-province. Two major, parallel, longitudinal structures can be traced in the mountains adjacent to the route; a frontal syncline, Castle Mountain syncline, located mainly east of the route; and a succeeding anticline, Bow River anticline, west of the route. The main depression axis of the syncline is located in Nigel Peak, mile 67.0, (115.0), that of the anticline, in Mt. Forbes, mile 97.5, (84.5). Because of the pitch of these folds, successive road level outcrops along the route expose strata of Proterozoic to late Mississippian age. At the south end of the route the road trends parallel and thence transverse to the westernmost Rocky Mountains Front Ranges. The lithological log of geologic sections exposed on this route, Plate 2B, and photogeologic maps, Plate 10B (in pocket), may be used jointly with the road log for guidance.

0.0 (182.0) Canadian National Railway level crossing at southwest outskirts of Jasper. The railway crosses the continental divide at Yellowhead Pass, 18 miles directly west. This pass, with an elevation of 3,711 ft., is one of the lowest passes across the Rockies on the continent.

0.1 (181.9) West—Branch road over Yellowhead Pass to Tete Jaune follows abandoned railway grades.

0.3 (181.7) East—Branch road to Athabaska River bridge, old Fort Point and Lac Beauvert Loop. Old Fort Point is site of trading post built by William Henry.

0.6 (181.4) East—Tekarra Lodge.

0.7 (181.3)	Bridge crossing Miette River; headwaters at Yellowhead Pass, confluence with Athabaska River directly east.
0.9 (181.1)	East—Mt. Tekarra (8,818 feet) in the Maligne Mountains. This range, composed of Lower Cambrian and/or Proterozoic quartzites and argillites, lies in hanging wall of easternmost Rocky Mountain Main Ranges' fault (Castle Mountain fault zone).
1.1 (180.9)	East—Cliffs of Lower Cambrian and/or Proterozoic quartzites in dip slopes of Maligne Mountains.
1.3 (180.7)	West—Kiefer Alpine Bungalows.
1.5 (180.5)	Southwest—Good view of Mount Edith Cavell (11,033 feet) composed of Lower Cambrian and Proterozoic beds dipping southwest in the west limb of an anticline. In the latitude of Lake Louise the anticline has been named Bow River anticline.
2.1 (179.9)	North—Pyramid Mountain (9,076 feet) composed of northeast-dipping beds of Lower Cambrian and Proterozoic argillites and quartzites, structurally continuous with Maligne Mountains.
2.8 (179.2)	West—The Whistlers (8,085 feet), directly south of it is Marmot Mountain. The names allude to the colonies of hoary marmots or whistlers which abound on the slopes.
3.4 (178.6)	Bridge crossing Whistlers Creek.
3.6 (178.4)	East—Becker's Bungalows.
3.7 (178.3)	East—Athabaska River, headwater tributaries fed by melt-water from Columbia Icefield near Mile 83.0 (64.0). The river debouches into Lake Athabaska 500 miles down-stream.
4.3 (177.7)	East—Amber Mountain (8,341 feet) in Maligne Mountains.
5.3 (176.7)	Southeast—Mt. Kerkeslin in synclinal axis; east limb of syncline in Mt. Hardisty. Each peak formed of Lower Cambrian quartzites. The syncline extends on strike in peaks along the route to Mile 158.0. In the latitude of Lake Louise it has been termed Castle Mountain syncline.
5.6 - 33.8 (N.A.)	Road outcrop of quartzites and argillites of Lower Cambrian and/or Proterozoic age.
5.9 (176.1)	Bridge crossing Portal Creek.
7.8 (174.2)	Bridge crossing Astoria River; Lower Cambrian and/or Proterozoic outcrops in channel.
7.9 (174.1)	West—Branch road to Mt. Edith Cavell (9 miles) and trail to Amethyst Lakes and the Ramparts.
8.6 (173.4)	East—Antler Mt. in Maligne Mountains.

9.1 (172.9) Southeast—Mt. Hardisty on east limb of Castle Mountain syncline.

11.0 (171.0) East—Shovel Pass on north slopes of Curator Mountain. Trail leads over pass to Medicine Lake. (Road sign misoriented.)

12.0 (170.0) West—Road outcrop of quartzites, grits and argillites.

12.6 (169.4) East—'Meeting of the Waters,' confluence of Athabaska and Whirlpool Rivers.

13.0 (169.0) East—Whirlpool River, rises on the continental divide.

13.5 (168.5) East—Valley of Crooked Trees directly east of road sign; trees apparently deformed in early growth by dead-fall.

14.0 (168.0) East—Whirlpool Warden Headquarters.

14.1 (167.9) Bridge crossing Whirlpool River. Whirlpool River trail on north bank leads westward 30 miles to Athabaska Pass on the continental divide. The Pass, discovered by David Thompson in 1811, made the Athabaska River an important highway for fur trade between the British Columbia and interior trading posts.

16.7 (165.3) Leach Lake and picnic grounds.

18.7 (163.3) West—Branch trail to Geraldine Lakes.

19.0 (163.0) Bridge at Athabaska Falls. Jointed, cross-bedded quartzites in falls are Lower Cambrian and/or Proterozoic, dipping northeast into Castle Mountain syncline.

19.1 (162.9) Bungalows and camp ground.

19.4 (162.6) East—Branch road to Canadian Youth Hostel.

19.5 (162.5) East—Mt. Kerkeslin (9,790 feet); hematitic band at bedding plane contact notable in lower quartzite cliff. Syncline in peak is structurally continuous with that in Nigel Peak, Mounts Coleman, Wilson, Murchison and Eisenhower.

19.7 (162.3) East—Athabaska District Warden Headquarters.

20.2 (161.8) West—Whirlpool Peak on south side of Whirlpool River. Northwest — Mt. Edith Cavell.

22.9 (159.1) West—Athabaska Lookout.

25.8 (156.2) West—Mt. Fryatt (11,026 feet) with cirques and hanging valleys.

26.4 (155.6) West—Mt. Christie (10,180 feet) formed of southwest-dipping Lower Cambrian strata. Named after Wm. J. Christie, Chief Factor, Hudson's Bay Company, who was in charge at Edmonton when Palliser's Expedition wintered there in 1858-59.

28.1 (153.9) East—North termination of Endless Chain Ridge; ridge composed of Lower Cambrian and Proterozoic clastics, mainly on east limb of Castle Mountain syncline. South plunge of fold is evident. The south route parallels this strike ridge to Mile 48.0.

29.2 (152.8) Crossing culvert of Ranger Creek.

30.7 (151.3) West—Viewpoint of valleys of Athabaska and Chaba Rivers. Prominent peak at river fork is Mt. Quincy (10,400 feet); Athabaska River flows on east side of Mt. Quincy, Fortress Lake and Chaba River lie on the west side.

31.2 (150.8) East—Branch road to Honeymoon and Osprey Lakes.

32.1 (149.9) East—Branch road to Buck Lake.

33.3 (148.7) West—Sunwapta garage and cabins.

N.A. (148.2-176.4) Road outcrop of quartzites and argillites of Lower Cambrian and/or Proterozoic age.

33.8 (148.2) East—Road outcrop of Middle Cambrian limestone preserved in trough of syncline; opposite limbs of syncline, composed of Lower Cambrian quartzites, visible in ridges on adjacent sides of valley.

41.0 - 42.0 (140.0-141.0) West—Roadside cliffs of flat-lying Cambrian quartzites located in trough of Castle Mountain syncline.

43.9 (138.1) Bridge crossing Poboktan Creek. Sunwapta District Warden Headquarters directly east. Contact of Lower Cambrian (Jonas formation) and Proterozoic (Hector formation), on east side of Endless Chain Ridge, crosses Poboktan Creek about 3½ miles upstream from bridge (not visible from road).

45.6 - 46.0 (136.0-136.4) East—Landslide of blocks of pink and white Lower Cambrian quartzites from Endless Chain Ridge. West—Sunwapta River breaks in rapids over blocks of slide, which is utilized extensively as source for decorative building stone in Jasper.

46.2 (135.8) Southeast—Good view of east scarp face of Sunwapta Peak. Lower Cambrian quartzites in lower portion of cliff, Mt. Whyte formation at level of slopes of brown talus, Middle Cambrian carbonates in upper cliff. Type section of Sunwapta Peak formation (Hughes, 1953) which is composed of 2,000 to 2,500 feet of Middle Cambrian limestones, dolomites and minor shales.

47.0 (135.0) Bridge crossing Jonas Creek. Lower Cambrian quartzites crop out on northeast side of bridge, Mt. Whyte formation on southwest side, transitional contact beneath bridge.

47.1 (139.4) East—Branch road leading to public camp ground.

47.4 - 48.0 (134.0-134.6) South—Good view of north end of Tangle Ridge. Type section of Tangle Ridge formation (Hughes, 1953), an Upper Cambrian carbonate sequence 1,900 feet thick, is located on lower slopes of ridge between altitures 6,900 and 8,760 feet. These beds are overlain by approximately 750 feet of Ordovician cherty limestones; these in turn by about ten feet of Ordovician Mt. Wilson quartzites on crest of knife ridge.

48.0 (134.0) East—South end of Endless Chain Ridge formed of Lower Cambrian quartzites on east flank of regional syncline. The north route parallels this strike ridge to Mile (153.9).

48.3 - 55.3 (126.7-133.7) Road outcrops of Middle Cambrian carbonates in trough of regional syncline.

50.3 (131.7) West—Sunwapta River.

50.7 (131.3) West—Middle Cambrian carbonates exposed on north face of mountain in an overturned anticline; a fault is inferred to separate this anticline from the syncline in ridges directly east.

51.9 (130.1) Bridge crossing Grizzly Creek.

52.7 (129.3) West—Mt. Whyte formation weathering brown in upper parts of ridges.

54.1 (127.9) Southeast—Massive limestones in cliff at base of Tangle Ridge are Middle Cambrian, upper slopes are formed in Upper Cambrian and Ordovician.

54.3 (127.7) Bridge crossing Beauty Creek. Stanley Falls 1,000 feet upstream, cut in flat-lying Middle Cambrian limestones; canyon below is in places 100 feet deep and less than 2 feet wide. Axis of syncline crosses route obliquely at bridge; northward from bridge the route is on east limb, southward, on west limb.

55.3 (126.6) East—Cliff of Middle Cambrian limestone on west limb of syncline.

55.4 - 57.8 (124.2 - 126.6) Road outcrop of thin-bedded argillaceous limestones of Mt. Whyte formation, exposed also in small rock islands in river channel. Strata dip 20 to 60 degrees east on west flank of syncline.

58.0 (124.0) Southwest—Stutfield Glacier on the upper slopes of Mt. Stutfield (11,320 feet), a northeast tongue of the Columbia Icefield. Many ice-falls can be seen.

58.0 - 59.1 (122.9 - 124.0) East—Road outcrop of Middle Cambrian carbonates, also in large talus blocks.

58.4 (123.6) North—Diadem Peak (11,060 feet) and Mt. Woolley (11,170 feet).

58.9 (123.1) West—Mt. Kitchener (11,500 feet), named after Viscount Kitchener, Secretary of State for War (1914-1916).

59.1 (122.9) Sharp switchback; fault contact of Middle Cambrian and lower Ordovician carbonates at turn. In this vicinity, the lower Ordovician is composed of 750 feet of cherty limestones (Formation 'A' of Hughes, 1953). This unit thickens and changes facies southward. At Mt. Wilson (Mile 96.5) the lower Ordovician consists of 2,000 feet of thin-bedded argillaceous and siliceous limestones (Mons and Sarbach formations of Walcott).

59.2 (122.8) Bridge crossing Tangle Creek. Road and channel outcrops are of lower Ordovician limestones. Mt. Wilson quartzite, ten feet thick, crosses the ridge directly above the bridge. The summit of Tangle Ridge (9,845 feet) can be easily reached by way of Tangle Creek and the south slopes. Plentiful fossils of the Upper Fairholme formation may be collected in the Devonian talus slope.

59.3 - 59.8 (122.2-122.7) Road outcrops of Ordovician carbonates.

60.5 (121.5) Summit Viewpoint. Mt. Kitchener on southwest, Mt. Stutfield on northwest. Sunwapta Canyon below cut in Middle Cambrian carbonates; brown-weathering shales on ridge on west side of canyon in Arctomys equivalent, superjacent limestones in Upper Cambrian.

61.2 - 61.3 (120.7-120.8) East—Road outcrops of light gray-weathering ribboned argillaceous limestones probably of Ordovician age.

61.3 - 61.9 (120.1-120.7) East—Road outcrops of thick-bedded, dark gray, dolomitic limestone of the Upper Cambrian. Cliffs directly west are formed of Middle Cambrian carbonates. Arctomys equivalent weathers brown on back slope.

62.0 (120.0) West—Broad alluvial plain, extending up Sunwapta River valley for about four miles to Dome and Athabaska glaciers, formed largely from outwash from moraines brought down by the glaciers from Columbia Icefields.

62.6 (119.4) East—Thin-bedded, Ordovician strata in cliff above dip approximately 70 degrees east in west limb of Castle Mountain syncline.

63.2 - 63.4 (118.6-118.8) East—Road outcrops of thin-bedded, buff and green-weathering limestone and shale of Upper Cambrian age.

63.5 (118.5) East—Mt. Wilcox composed of Upper Cambrian and Ordovician strata.

63.8 (118.2) West—Dome Glacier. Mt. Kitchener forms north wall of glacial valley.

64.0 - 64.1 (117.9-118.0) East—Road outcrop of thin-bedded, Upper Cambrian beds.

64.4 (117.6) West—Branch road to base of Athabaska Glacier, a northeast ice-flow of the Columbia Icefield. With its outlet glaciers, the Columbia Icefield covers an area of nearly 150 square miles; more than 50 square miles of the field is 8,500 feet above sea-level. From the great central ice reservoir, lying between Snow Dome, Mt. Castleguard and Mt. Columbia, and capping the continental divide for a distance of about 20 miles, three main valleys radiate outward. Through these valleys flow the Athabaska Glacier to the northeast, the Saskatchewan to the east, and the Columbia to the northwest. In addition to the three main glaciers, small tongues of ice flow in-

to surrounding valleys, and at a number of points ice tumbles over precipices to form reconstructed glaciers. Dome Glacier, visible directly north of this stop, is one of these small ice-tongues.

The Columbia Icefield is the source of three great rivers: the 765 mile Athabaska, a sub-tributary of the MacKenzie River which flows into the Arctic Ocean; the 1,205 mile Saskatchewan which crosses the prairies and empties into Lake Winnipeg and thence into Hudson Bay; and the 1,210 mile Columbia which crosses into northwest U.S.A. before debouching into the Pacific Ocean.

An excellent view of the Athabaska Glacier may be obtained from the readily accessible vantage point several hundred feet up the slope of Wilcox Peak directly east of this stop.

The Athabaska Glacier moves forward about 50 feet per year but the margin retreats approximately 100 feet. Thus about 150 lateral feet of the glacier front is wasted annually. The position of the crevasses and the ice margin changes visibly over a period of several days. The glacier lake at the foot of the glacier in the foreground has a diurnal rise and fall of about two feet, dependant upon the flow of superficial glacial streams.

Ground moraine with parallel and transverse ridges, knife-edged lateral moraines and terminal moraines of the Athabaska Glacier can be seen. The high lateral moraines, which rise 70 feet above the present ice surface, are thought to be the result of an ice-advance with its culmination about 1890. Terminal moraines, possibly from this same advance, extent about ½ mile in front of the glacier.

During the summer tourist season, trips by snowmobile may be taken over the Athabaska Glacier. Superficial streams, moulins, seracs, bergschrund and other typical valley glacier phenomena may be seen.

64.6 (117.4) East—Columbia Icefield Chalet.

65.2 (116.8) East—Branch road to public camp ground.

65.3 (116.7) South gate, Jasper National Park; north gate, Banff National Park.

67.0 (115.0) East—Nigel Peak (10,535 feet), approximately at locus of central depression of regional northwest-trending Castle Mountain syncline. Uppermost 500 feet of strata in peak are lower Rundle formation (Dessa Dawn formation of Laudon, 1949; Spreng, 1952). Banff formation in upper slope with dark band at base possibly representing the Exshaw formation, Palliser formation in lower cliffs, Fairholme underlies talus as base.

68.3 (113.7) East—Headwaters tributary of North Saskatchewan River, ultimately debouching into Hudson Bay.

68.8 (113.2) Summit of Sunwapta Pass, elevation 6,694 feet.

69.2 (112.8) Bridge crossing Hilda Creek.

69.3 (112.7) West—Hilda Creek Canadian Youth Hostel.

70.7 (111.3) Northeast—Palliser limestones in knob hill overlain by Banff formation in broad saddle, further overlain by ledges of lower Rundle limestone in ridges. Palliser is on west limb of syncline, Banff in trough axis, Rundle on east limb.

72.3 - 74.0 (108.0-109.7) South from double switchback, profile of west face of Mt. Coleman. Lower Rundle (Dessa Dawn formation of Laudon, 1949) in cliffs in peak, long slope with ledges is in Banff formation, lower scarp in Palliser, Fairholme on low slope which extends into valley. Mt. Coleman named after Emeritus Professor A. P. Coleman, Toronto, Canadian geologist who explored the Rockies between North Saskatchewan and Athabaska River. (See Plate 6).

74.3 - 74.4 (107.6-107.7) Road outcro pof vuggy, light gray limestone of upper part of Fairholme formation.

74.3 (107.7) Bridge crossing North Fork of Saskatchewan River. Light gray Fairholme beds in head of gorge on west side of bridge. West—View of profile of Mt. Athabaska spur ridge. Palliser formation in cliff, Fairholme in slope, Mt. Wilson quartzite weathering white at top of ridge. Discordance of dips of these strata with those in mountain directly west probably indicates a fault in gorge at west end of ridge. The Devonian-Ordovician section is readily accessible from top of talus apron.

74.8 (107.2) East—Road outcrop of dark gray to black, fine-crystalline, *Amphipora*—bearing dolomites of the Fairholme formation.

75.1 (106.9) Bridge crossing North Fork of Saskatchewan River. Canyon at bridge 100 feet deep and only a few feet wide, cut in Devonian carbonates.

75.2 (106.8) East—Road outcrop of Fairholme formation.

75.4 (106.6) Bridge crossing Nigel Creek. Upper Fairholme and Alexo formations crop out in creek channel east from bridge.

76.5 (105.5) Bridge crossing Big Hill Creek.

76.7 (105.3) West—Tumble Creek camp ground.

76.8 (105.2) Bridge crossing Tumble Creek. Waterfalls directly east, tumble over cliff of Palliser limestone.

77.3 (104.7) Northwest—Nearly vertically dipping Fairholme dolomites on west bank of Saskatchewan River, on west limb of Castle Mountain syncline.

77.5 (104.5) East—Cliff of massive Palliser limestone.

78.0 - 78.2 (103.8-104.0) East—Road outcrop of light gray, vuggy dolomites of upper part of Fairholm formation.

78.7 (103.3) East—Break of massive limestone in cliff to subjacent, medium-bedded limestone marks Palliser-Alexo contact.

79.3 (102.7) South—Good view of cliff-forming, white-weathering Mt. Wilson quartzites on west face of Mt. Coleman. Slight gulley directly north of cliffs of Mt. Wilson formation offers easy access to observation of the Ordovician "Halysites beds" and the Fairholme-Alexo sequence. These strata on west limb of the Castle Mountain syncline, north plunge of which can be observed.

79.5 - 80.0 (102.0-102.5) East—Light cream talus blocks at roadside exhibit typical lithology of the Mt. Wilson formation. Blocks derived from cliff directly above.

80.3 (101.7) West—Footbridge crosses North Saskatchewan River. Green argillaceous limestone of the Ordovician dips 70 degrees northeast on west limb of syncline.

80.5 - 80.7 (101.3-101.5) West—Outcrop in canyon walls of ripple-marked, buff to green Ordovician limestones. Middle Cambrian limestone in peaks directly west.

81.4 - 81.6 (100.4-100.6) East—Road outcrop of ribboned Ordovician limestones (Mons and Sarbach formations of Walcott, 1920 and 1923).

81.5 (100.5) East—Mt. Coleman camp grounds.

81.8 - 83.0 (99.0 - 100.2) West—Brown-weathering shales and limestones of basal Upper Cambrian Arctomys formation on east slopes of Mt. Saskatchewan.

82.2 (99.8) East—On west face of Mt. Coleman, Ordovician Mons and Sarbach formations in lower slopes, Mt. Wilson formation in cliff, Devonian sequence above.

82.6 (99.4) West—Road outcrop of massive Upper Cambrian limestones (Lyell formation of Walcott, 1923).

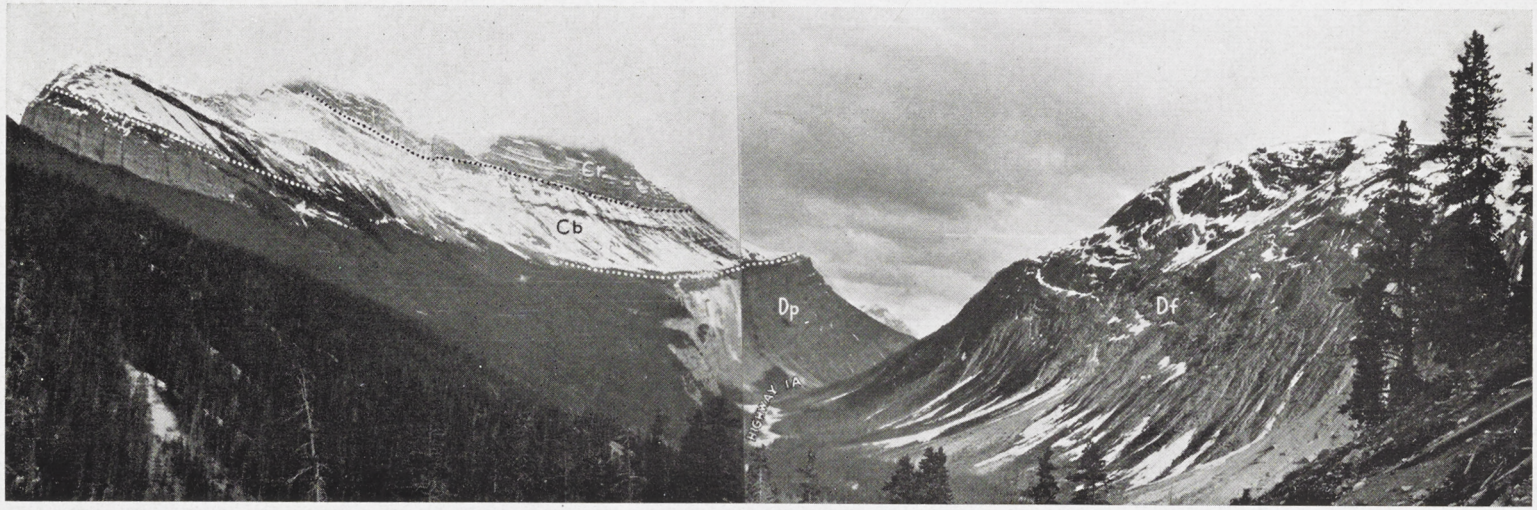
83.2 - 84.8 (97.2 - 98.8) Road outcrop of Upper Cambrian limestones (Lyell formation). Contact with overlying Ordovician (Mons and Sarbach formations) is probably at top of small cliff in lower slopes above road.

84.9 (97.1) West—Mt. Amery (10,940 feet) with flat-lying beds of the Upper Cambrian (Sullivan and Lyell formations) exposed in peak; located approximately in the crest of Bow River anticline.

85.0 (97.0) Northwest—Confluence of east-flowing Alexandra River and North Saskatchewan River; Mt. Saskatchewan and the Castelets on north side of Alexandra River; Mt. Amery on south side.

85.2 (96.8) East—Emergency telephone; Canadian Youth Hostel and trail to Sunset Pass and Pinto Lake. Upper Cambrian Lyell and Sullivan formations have aggregate thickness of 1,000 feet on west side of pass.

85.3 (96.7) Northeast—Mt. Coleman.



Mt. Coleman. Looking southeast from mile 73.0 (109.0), roadlog 22. Rundle (Cr), Banff (Cb), Palliser (Dp), Fairholme (Df).

Photography by A. H. Ellison

Plate VI

85.4 (96.6) East—Northwest slope of Mt. Wilson. Prominent cliff above mid-elevation formed of Mt. Wilson quartzite, Devonian dolomites above, Ordovician limestones below.

85.5 (96.5) Culvert of Norman Creek.

85.5 - 87.4 (94.6 - 96.5) East—Road outcrop of medium to thick-bedded, dark gray limestones of the Upper Cambrian (Lyell formation).

88.1 (93.9) Bridge crossing Rampart Creek. Bedded Ordovician limestones on high cliffs directly east; massive limestones of Upper Cambrian (Lyell formation) exposed in cliff on south bank of Rampart Creek.

92.5 (89.5) Bridge.

92.7 (89.3) West—Tributary valley of Arctomys Creek with Mt. Hooge on north side and Mt. Erasmus on south side. Arctomys Creek is fed by melt waters from glaciers on the southeast side of Mt. Lyell (11,495 feet) at the Continental Divide. Mt. Lyell is named after Sir Charles Lyell (1795-1875), noted British geologist.

93.8 (88.2) West—Survey Peak (8,781 feet), composed of Ordovician and Upper Cambrian strata.

96.4 (85.6) South—Structure profile of syncline in Mt. Murchison (10,936 feet). Devonian strata in peak, Ordovician strata in medial part, Upper Cambrian in lower slopes. The mountain was named by Hector, 1859, after Sir Roderick Impey Murchison (1792-1871), Director General of the Geological Survey of Great Britain who recommended Hector for the post of Surgeon and Geologist to the Palliser Expedition.

96.5 (85.5) North—Mt. Wilson (10,631 feet), type locality of the Mt. Wilson formation (Walcott, 1923); formation is composed of approximately 550 feet of thick to massive beds of quartzose sandstone. Mt. Wilson formation is directly overlain by Devonian and underlain by a thick sequence of Ordovician and Upper Cambrian carbonates (see Plate 7).

96.7 (85.3) East—North Saskatchewan Cabins and Service Station.

97.4 (84.6) Bridge crossing main channel of North Saskatchewan River. Peaks and west slopes of Brazeau Range visible through gap to the east. That range is the westermost Front Range at this latitude and is located in the foot wall block of the Castle Mountain fault zone.

97.5 (84.5) Bridge crossing south channel of North Saskatchewan River. West—Mt. Outram (10,670 feet) and Mt. Forbes (11,902 feet) visible at head of tributary valley of Howse and Glacier Rivers. Mt. Forbes is capped by Rundle limestones with the Devonian sequence (Pipestone and Messine formations of Walcott) exposed in upper slopes and underlain by Ordovician (Mons and Sarbach), Upper Cambrian Lyell formation exposed in basal cliffs on north side.

97.6 (84.4) East—North Saskatchewan Warden Headquarters.

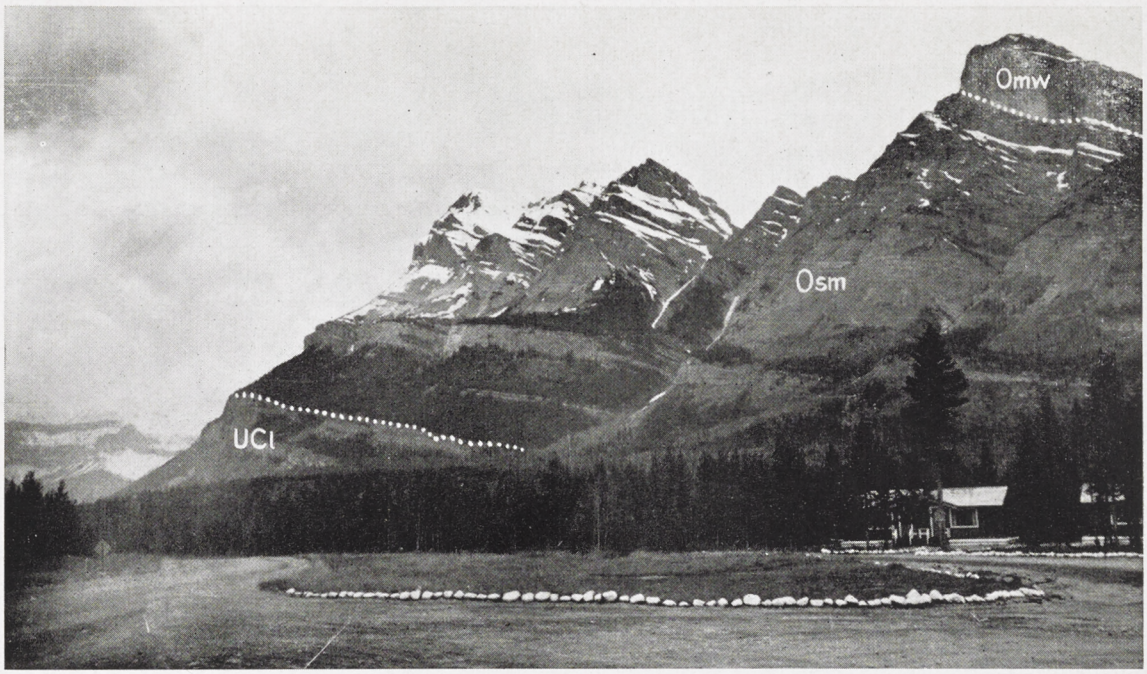


Plate VII

Mt. Wilson. Looking northeast from mile 96.5 (85.5), road log 2. Mt. Wilson (Omw), Sarback and Mons (Osm), Lyell (UCl).

Photography by A. H. Ellison

98.5 (83.5)	Viewpoint—North-flowing Mistaya River occupies main valley, Howse River in tributary valley to west. Trail to Howse and Bush Passes on south side of Howse River.
100.0 (82.0)	West—Mistaya Canyon Trail.
100.6 (81.4)	East—Mt. Murchison (10,936 feet). Light-weathering strata of Mt. Wilson formation in cliff; Ordovician sequence in lower slopes.
101.7 (80.3)	North—Structure profile of syncline in Mt. Wilson.
101.8 - 101.9 (80.1 - 80.2)	East—Road outcrop in Upper Cambrian limestone.
102.0 (80.0)	West—Mt. Sarbach (10,260 feet), directly south of which are Kaufmann Peaks (10,150 and 10,200 feet); named after two Swiss guides, Peter Sarbach and Christian Kaufmann, who accompanied Collie upon many 'first ascents' in this area. Type section of the Sarbach formation (Walcott, 1923) in Mt. Sarbach; Mt. Wilson quartzites form cliff near peaks.
102.4 (79.6)	Bridge.
104.2 (77.8)	Culvert at Bison Creek.

106.5 (75.5) Bridge crossing Totem Creek.

106.6 (75.4) West—Canadian Youth Hostel.

107.4 (74.6) West—Mt. Chephren (10,715 feet) capped with Ordovician strata. Mountain originally named 'Pyramid' but changed in 1918 to Chephren (name of second great pyramid of Egypt) to avoid duplication with the Pyramid Mt. directly north of Jasper.

108.0 (74.0) West—Lower Waterfowl Lake.

108.6 (73.4) West—Lower Waterfowl camp ground.

109.1 (72.9) Bridge crossing Noyes Creek.

109.2 (72.8) Bridge.

109.7 (72.3) West—Emergency telephone.

109.8 (72.2) West—Upper Waterfowl Lake.

109.9 (72.1) West—Mt. Synge composed dominantly of Middle Cambrian strata; Lower Cambrian beds underlie forested slopes at base.

111.2 (70.8) East—Lower Cambrian quartzite plunges north into subsurface, comes to surface again at Mile 47.0 (135.8), up-plunge from central depression of Castle Mountain syncline.

111.8 (70.2) East — Mt. Noyes (10,040 feet), with brown-weathering limestones of basal Middle Cambrian Mt. Whyte formations exposed in lower slopes.

111.9 (70.1) West—Sharp, pyramidal mountain is Ebon Peak (9,600 feet).

112.4 (69.6) Bridge crossing Silverhorn Creek.

113.0 - 113.6 (68.4 - 69.0) East—Red quartzite boulders in alluvium are typical of Lower Cambrian lithology.

113.7 (68.3) East—Outcrops in ridges above road are Lower Cambrian quartzite.

116.2 - 117.0 (65.0 - 65.8) West—Barbette Mt. (10,080 feet) at head of tributary valley, Mistaya Mt. (10,100 feet) on south side of valley and Mt. Patterson (10,490 feet) on north side. These mountains are composed dominantly of Middle Cambrian carbonates; Lower Cambrian clastic in lower slopes.

117.8 (64.2) Road outcrop of Lower Cambrian quartzites.

117.8 (64.2) Southwest—Peyto Glacier and Peyto Peak.

118.3 (63.7) East—Mt. Whyte formation weathering red above Lower Cambrian quartzites in lower slopes of Mt. Weed.

118.4 (63.6) Bridge.

118.5 (63.5) Bridge.

119.6 (62.4) East—Observation Peak (10 214 feet), composed of Lower and Middle Cambrian beds.

120.0 (62.0) West—Branch road leads ¾ mile to Peyto Lake Lookout.

120.1 (61.9) Bow Summit (6,878 feet). Separates north-flowing Mistaya River of the North Saskatchewan drainage basin from south-flowing tributaries of Bow River.

121.0 (61.0) East—Mistaya District Warden Headquarters.

121.7 (60.3) East—Bow Summit camp ground.

122.0 (60.0) East—Cirque Peak (9,768 feet) formed of Lower Cambrian and Middle Cambrian strata.

122.9 (59.1) West—Mt. Thompson (10,119 feet). Middle Cambrian in upper cliffs.

123.0 (59.0) West—Branch road to Num-ti-jah Lodge.

123.1 (58.9) West—Bow Glacier. Portal Peak on south side of glacial valley, Mt. Thompson on north side; peak of each mountain formed of Middle Cambrian carbonates.

123.6 (58.4) West—Bow Lake with unnamed peaks on southwest side. Lake level is 1,800 feet above elevation of Banff townsite.

124.0 - 144.0 (N.A.) Road outcrop of Proterozoic quartzite, conglomerate and argillite of Hector formation.

125.0 (57.0) West—Crowfoot Glacier. Upper 'toe' of glacier overlies the Mt. Whyte formation; cliffs above in Cathedral formation; cliffs below 'toe' formed of Lower Cambrian quartzites.

127.5 (54.5) Bridge crossing Helen Creek. Lower Cambrian quartzites exposed in channel.

128.1 (53.9) East—Dolomite Peak, formed of Middle Cambrian formations.

129.3 (52.7) Southeast—Profile of north ridge of Mt. Hector. Eldon dolomite forms uppermost cliff, Stephen formation in well developed shoulder, Cathedral

formation in low cliff, Mt. Whyte formation in small lower shoulder, Lower Cambrian quartzites exposed in basal one third of mountain. This ridge lies on west limb of Castle Mountain syncline.

130.3 (51.7) Bridge crossing Mosquito Creek, Molar Creek Trail on southeast side, emergency telephone directly west.

130.4 (51.6) East—Camp ground; West—Canadian Youth Hostel.

131.0 (51.0) Bridge crossing No-see-um Creek.

131.5 (50.5) West—Bow Peak, composed mainly of Lower and Middle Cambrian strata.

132.5 (49.5) Bridge crossing Hector Creek.

133.1 (48.9) North — Structure profile formed by several mountains displays Bow River anticline on west and Castle Mountain syncline on east.

133.8 (38.2) East—View of Mt. Hector (11,135 feet), composed dominantly of Proterozoic and Lower Cambrian quartzites and Middle Cambrian carbonates. Mt. Hector was named by Dawson (1884) after Sir James Hector, M.D. (1834-1907), surgeon and geologist to the Palliser Expedition, 1857 to 1860, director of the Geological Survey of New Zealand 1865 to 1905; Hector revisited the scene of his Canadian explorations in 1904.

134.0 - 148.0 (34.0 - 48.0) Route south is located approximately on the axis of Bow River anticline.

134.7 (47.3) West — Hector Lake. Pulpit Peak on west shore located in north end of Waputik Range. Forested slopes underlain by Proterozoic and Lower Cambrian quartzites, Middle Cambrian sequence in twin cliffs. Waputik Range forms west limb of Bow River anticline. Waputik is Stoney Indian for white Rocky Mountain goat.

135.0 (47.0) East—Road outcrop of argillites of Proterozoic Hector formation.

135.2 (46.8) Bridge.

136.5 (45.5) Bridge.

138.1 (43.9) North—Good view of Bow Peak formed of flat-lying Middle and Lower Cambrian strata in axial zone of Bow River anticline.

138.9 (43.1) East—Emergency telephone.

139.8 (42.2) West—Waputik Range formed dominantly of Lower and Middle Cambrian strata on west limb of Bow River anticline. Remarkable succession of cirques, aretes and hanging valleys occur on east face.

143.4 (38.6) West—Mt. Bosworth (9,093 feet) at south termination of Waputik Range. From wooded slopes at the base to the peak there are exposed sediments

of Lower and Middle Cambrian ages. Upper Cambrian beds are exposed in Paget Peak, directly west of Mt. Bosworth. The mountain is the type locality of Cathedral, Bosworth, Paget and Sherbrook formations (Walcott, 1908).

143.5 (38.5) West—Gap of Kicking Horse Pass (elevation 5,339 feet) with Waputik Range on north side; Bow Range on south side. Trans-Canada Highway and Canadian Pacific Railway traverse the pass.

143.6 (48.4) West—Mt. Niblock (9,764 feet) at north termination of Bow Range. Mt. St. Piran forms southeast spur; type section St. Piran formation (Walcott, 1908) on its eastern slopes.

N.A. (38.0 - 57.0) Road outcrops of Proterozoic quartzites, conglomerates, and argillites of the Hector formation.

143.9 - 145.7 (36.3 - 38.1) Road outcrop of Proterozoic grits and argillites of the Hector formation.

146.3 (35.7) East—Lake Louise Information Bureau.

146.6 (35.4) East—Slate Mountain group. Ptarmigan Peak visible through prominent gap. Redoubt Mt. is directly on south side of gap, Mt. Richardson on north side. These mountains, composed of Proterozoic and Lower and Middle Cambrian sediments, are in hanging wall of Castle Mountain thrust. Type sections of Proterozoic Hector formation (Walcott, 1910) and Lower Cambrian Fort Mountain formation (Walcott, 1917) are in Redoubt Mountain, formerly known as Fort Mountain.

146.7 (35.3) Canadian Pacific Railway level crossing; railway passes westward over Kicking Horse Pass.

146.75 (35.25) West—Branch road to Lake Louise Station and Post Office.

146.8 (35.2) Bridge crossing Pipestone River.

147.0 (35.0) Road junction. Trans-Canada Highway branches west to Kicking Horse Pass and beyond.

148.0 (34.0) Canadian Pacific Railway level crossing.

148.3 (33.7) West — Mt. Temple (11,636 feet). Middle Cambrian (Eldon, Stephen, Cathedral and Mt. Whyte formations) form upper half of mountain, Lower Cambrian quartzites and Proterozoic quartzites and argillites at base.

148.7 (33.3) West—Road outcrop of Proterozoic Hector formation.

149.2 (32.8) Bridge crossing Corral Creek. Type section of Proterozoic Corral Creek formation (Walcott, 1910), composed of approximately 1,300 feet of coarse-grained, light gray sandstone, with a few thick layers of quartz pebble conglomerate. Corral Creek formation underlies the Hector formation conformably.

149.4 (32.6) East—Corral Creek camp ground.

151.6 (30.4) West—Valley of the Ten Peaks leading to Moraine Lake. Deltaform Mountain (11,235 feet), the highest of the Ten Peaks, visible through gap. Cliffs are formed of Lower and Middle Cambrian, with thin sections of Upper Cambrian carbonates in peak.

154.5 (27.5) Bridge crossing Baker Creek.

155.4 (26.6) West—Mt. Fay (10,622 feet).

156.6 (25.4) West—Eldon Station, after which the upper cliff-forming Middle Cambrian carbonate unit on Mt. Eisenhower was named (Walcott, 1908).

159.2 (22.8) West—Windermere Highway traverses Vermilion Pass in prominent gap on opposite side of valley, Boom Mt. located on the north side of pass; Storm Mt. on south side.

160.5 (21.5) East—Mt. Eisenhower, formerly Castle Mt., with upper and lower cliffs in Middle Cambrian Eldon and Cathedral formations, medial shoulder in Stephen formation; Mt. Whyte formation, Lower Cambrian quartzite series, and Proterozoic strata in slopes below cliff. Mt. Eisenhower lies on the common limb of Bow River anticline on west, and Castle Mt. syncline on east. Upper Cambrian Arctomys and Bosworth formations exposed in Stuart Knob in axial zone of the syncline, here hidden from view. (See Plate 8).

163.2 (18.8) Road junction. Windermere Highway goes west via Vermilion Pass (5,416 feet) to Radium Hot Springs and northwestern U.S.A.

163.3 (18.7) West—Canadian Youth Hostel.
East—Mt. Eisenhower Park Warden Headquarters.

163.7 (18.3) East—Mt. Eisenhower camp grounds.

164.0 (180.) Approximate surface position of oblique segment of Castle Mountain thrust.

166.1 - 166.5 (15.5 - 15.9) East—Scattered road outcrop of Paleozoic (Rundle?) carbonates.

167.0 (15.0) Bridge crossing Johnston Creek.
West—Copper Mountain composed of Middle Cambrian strata.

168.2 to 169.7 (12.3 to 13.8) East—Road outcrop of Triassic Spray River siltstone in axial zone of syncline. Red colouration of soil due to ferruginous material in Triassic sequence.

169.6 (12.4) West—Mt. Ball (10,865 feet) visible through gap; situated in hanging wall of Castle Mountain thrust; mountains in foreground on either side of gap are in the foot wall.

170.0 (12.0) East—Mt. Ishbel, formerly called Mt. Sawback, composed of nearly vertical Devonian and Mississippian in east limb of syncline (Sawback Range). Bow River valley lies in trough of syncline.

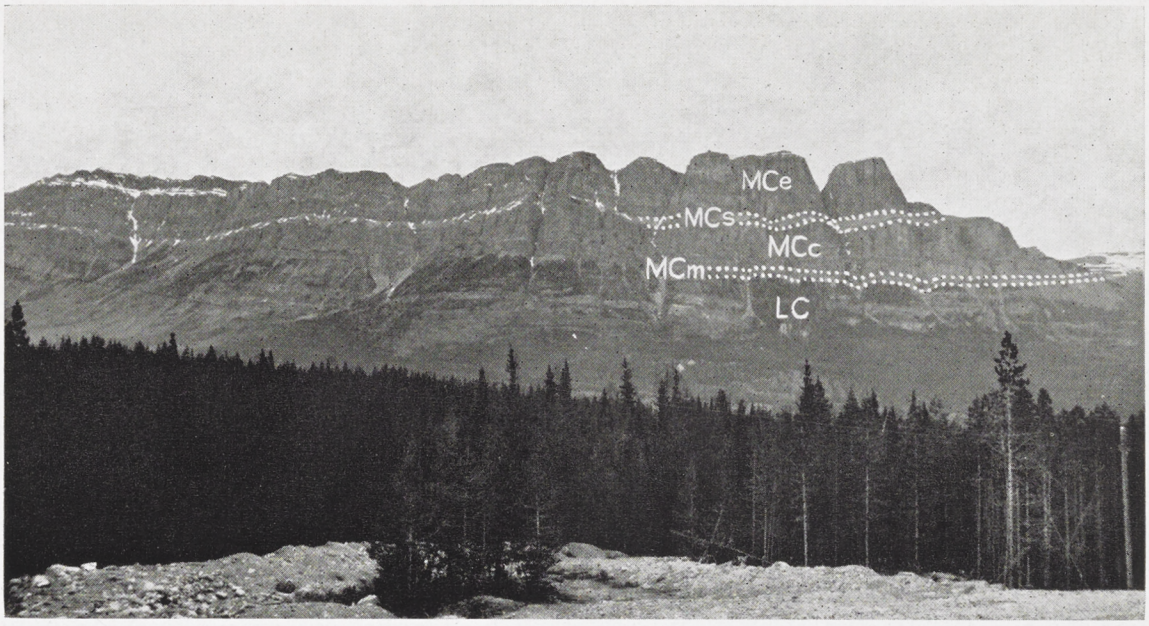


Plate VIII

Mt. Eisenhower. Looking west from Vermilion Pass. Eldon (MCe), Stephen (MCs), Cathedral (MCc), Mt. Whyte (MCm), Lower Cambrian series (LC).

Photograph by A. H. Ellison,

170.6 (11.4)	West—Branch road to Redearth Creek and trail to Pilot Mountain and Mt. Ball. Pilot Mountain, directly west, is formed of anticlinally folded Mississippian and Devonian carbonates. Upper cliff in Rundle formation; lower cliff in Palliser formation.
170.7 (11.3)	Tree in road.
171.0 (11.0)	Northeast—Sawback Range, structurally continuous with Bourgeau Range on strike directly southeast; fourth front range at this latitude.
174.4 (7.6)	Northeast—Mt. Cory (9,194 feet) formed of nearly vertical limestones of Palliser formation.
174.9 (7.1)	Northeast—'Hole in the Wall' in Palliser limestone, at south terminus of Sawback Range. West—Massive Range, composed of anticlinally folded Mississippian and Devonian strata exposed in peaks of Mt. Brett, Mt. Bourgeau and Massive Mountain.
175.8 - 175.9 (6.1 - 6.2)	North—Road outcrop of Palliser limestone.
176.2 - 176.3 (5.7 - 5.8)	North—Road outcrop of vuggy Fairholme dolomite.
176.5 - 176.6 (5.4 - 5.5)	'Rocky Mountain Goat Range' sign points to bedded argillaceous limestone and shales of the Ordovician (Goodsir group).
177.2 - 177.3 (4.7 - 4.8)	North—Road outcrop of Upper Cambrian limestones (Ottertail formation); also exposed in massive beds in slopes above roadside.

177.3 (4.7)	North—Red-weathering shales of basal Upper Cambrian Arctomys formation exposed in slopes above roadside. The Arctomys is here located directly in the hanging wall of the Bourgeau fault; fault slice of Palliser limestone forming Mt. Edith occurs in the foot wall.
178.0 (4.0)	Bridge.
178.4 (3.6)	Crossing Trans-Canada Highway right-of-way.
178.8 (3.2)	North—Mt. Edith (8,380 feet) visible through gap; formed of Palliser limestone.
179.0 - 179.4 (2.6 - 3.0)	North—Road outcrop of Rundle and Rocky Mountain formations.
180.0 (2.0)	South—Vermilion Lakes with beaver dams and houses directly below roadside.
180.1 (1.9)	North—Profile of Mt. Norquay; Upper Paleozoic formations in strike continuity with those on Sulphur Mt. on opposite side of valley. Bourgeau Range is west of Sulphur Mt.; Rundle Range on east. Prominent pair of cliffs in each range formed of Rundle and of Devonian limestones. (See Plate 9.)
180.8 - 181.0 (1.0 - 1.2)	North—Road outcrop of Devonian carbonates.
181.5 (0.5)	North—Branch road to 'Green Spot' and chair lift on Mt. Norquay.
181.8 (0.2)	Bridge crossing Fortymile Creek.
182.0 (0.0)	Canadian Pacific Railway level crossing; Banff station directly east, elevation 4,538 feet.

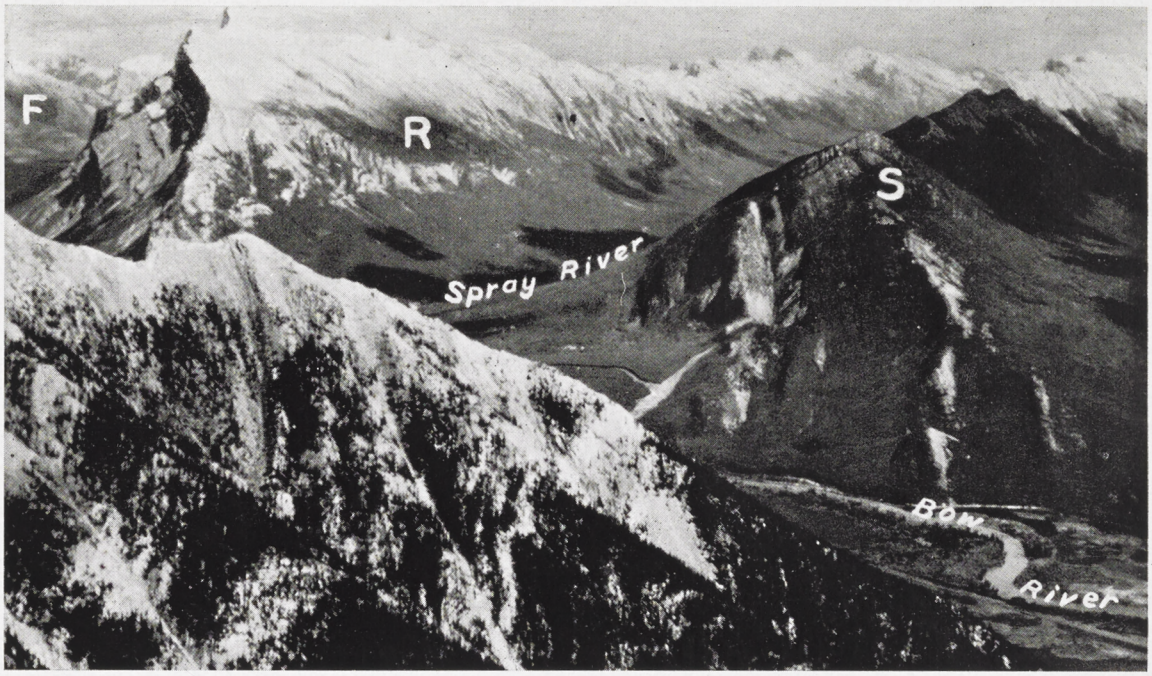


Plate IX

View illustrating typical Rocky Mountain structure and range development in vicinity of Banff. Looking east across Bow River from ridge of Mount Edith. Sulphur Mountain Range (S), Mount Rundle Range (R), Fairholme Range (F). Each range is bounded on east by a thrust fault and is composed of westward-dipping Devonian and Mississippian strata. Subsequent valleys are carved in Mesozoic rocks.

Photograph by L. M. Clark.

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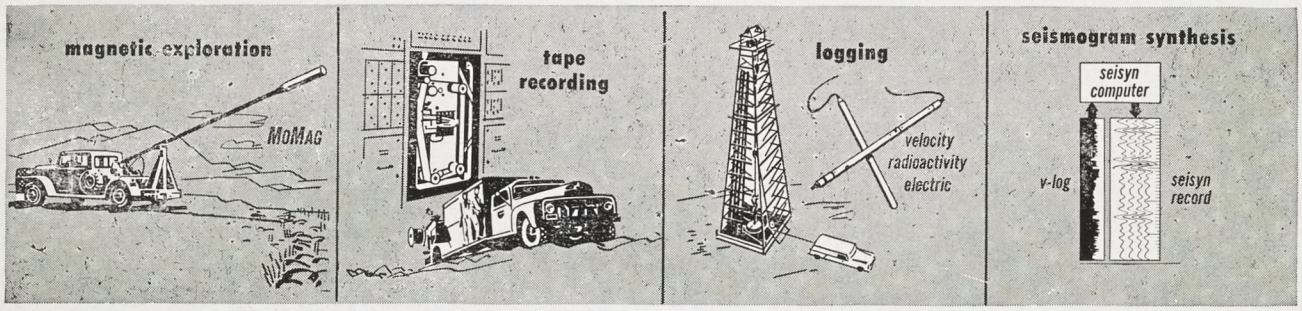
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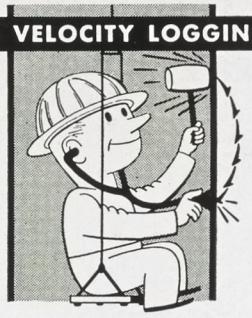
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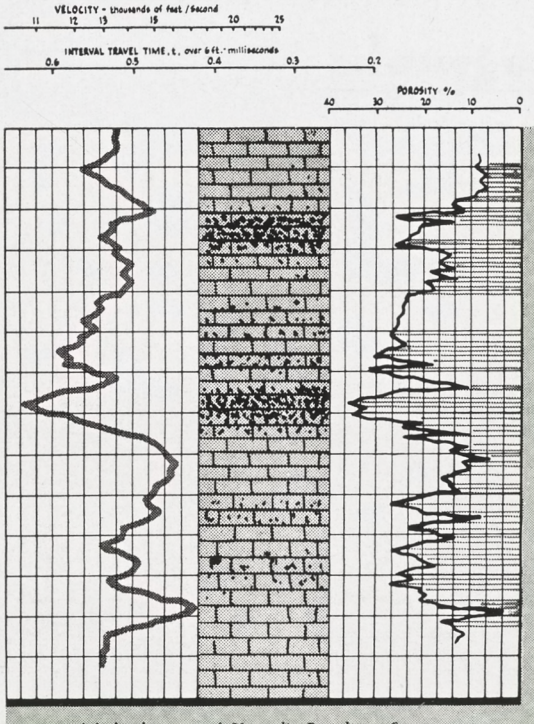
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Autographs

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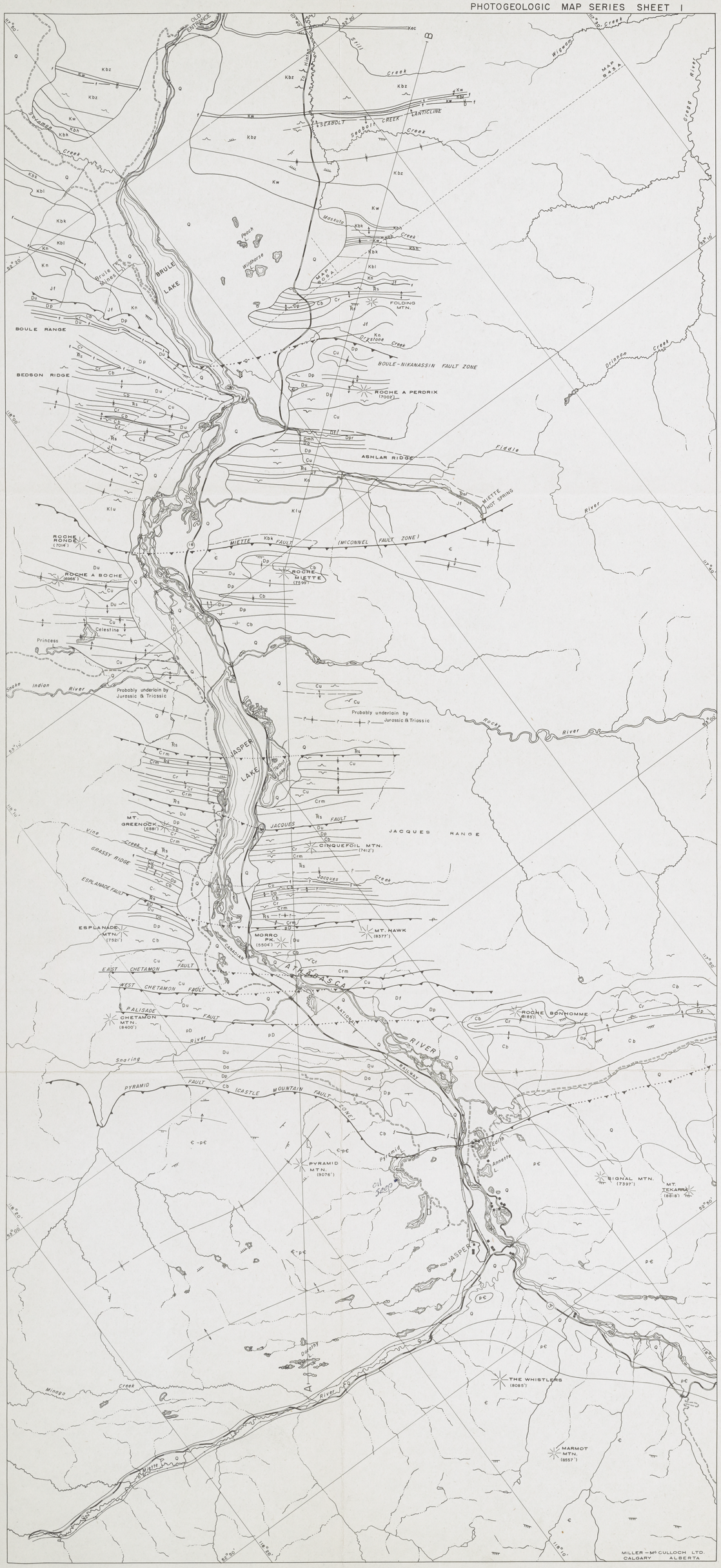
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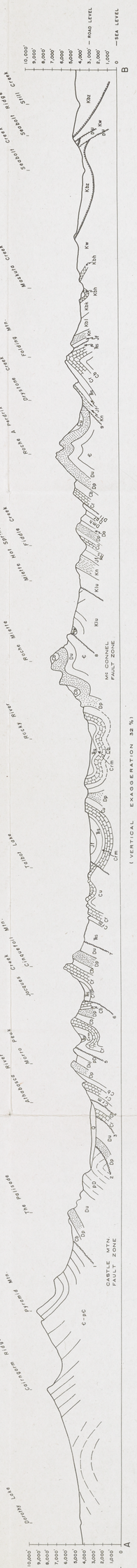
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Scale
1: 126,720
1 inch = 2 miles

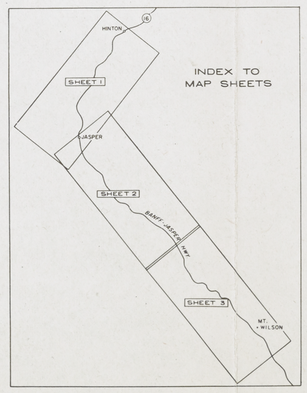
0 1 2 3 4 5 6 7 8 miles

LEGEND

QUATERNARY	Q	Recent Alluvium and glacial deposits
UPPER CRETACEOUS	Kec	Entrance conglomerate
	Kbz	Brazeau formation
	Kw	Wapiabi formation
	Kbh	Bighorn formation
	Kbk	Blackstone formation
LOWER CRETACEOUS	Kbl	Blairmore formation
	Kn	Nikanassin formation
	Klu	Lower Cretaceous undivided
JURASSIC	Jf	Fernie group
TRIASSIC	Rs	Spray River formation
CARBONIFEROUS	Crm	Rocky Mountain formation
	Cr	Rundle group
	Cb	Banff formation
	Cu	Carboniferous undivided or partially undivided
DEVONIAN	Dp	Palliser formation
	Da	Alexo formation
	Dmh	Mount Hawk formation
	Dpr	Perdrix formation
	Dfl	Flume formation
	Du	Devonian undivided or partially undivided
pre-DEVONIAN (Paleozoic)	pD	
CAMBRIAN	€	
pre-CAMBRIAN	p€	

SPECIAL GEOLOGIC SYMBOLS

- Dip group 1, 1°–3°
- Dip group 2, 3°–10°
- Dip group 3, 10°–25°
- Dip group 4, 25°–45°
- Dip group 5, 45° to nearly vertical



Alberta Society of Petroleum Geologists
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LEGEND

DEVONIAN

8 — DEVONIAN SYSTEM

ORDOVICIAN

MOUNT WILSON FORMATION

6 — FORMATION A.

CAMBRIAN

UPPER CAMBRIAN

5 — TANGLE RIDGE FORMATION

MIDDLE CAMBRIAN

4 — SUNWAPTA PEAK FORMATION

MIDDLE AND LOWER CAMBRIAN

3 — MOUNT WHYTE FORMATION

PRECAMBRIAN AND (?) LOWER CAMBRIAN

2 — JONAS CREEK FORMATION

PRECAMBRIAN

1 — HECTOR FORMATION

BEDDING (INCLINED, VERTICAL, HORIZONTAL, OVERTURNED)

ANTICLINAL AXIS (ARROW SHOWS DIRECTION OF PLUNGE)

SYNCLINAL AXIS (ARROW SHOWS DIRECTION OF PLUNGE)

PLUNGE OF MINOR ANTICLINAL AXIS

PLUNGE OF MINOR SYNCLINAL AXIS

FAULT

FOSSIL LOCALITY — F11

BANFF - JASPER HIGHWAY

TRAIL

CABIN

TRIANGULATION STATION

PARK BOUNDARY

INTERMITTENT STREAM

MARSH

GLACIER

CONTOURS (INTERVAL 500' FEET) — 7500

HEIGHT IN FEET ABOVE MEAN SEA-LEVEL — 10,902

GENERALIZED STRATIGRAPHIC SECTION

DEVONIAN SYSTEM 1500'± — TENTACULITES (F18)

MT WILSON FORMATION 20' — (F16)

FORMATION A 750'±

TANGLE RIDGE FORMATION 1900'± — CEDARIA (F15, F22, WEN)

SUNWAPTA PEAK FORMATION 2000 - 2300' — THOMPSONASPIS (F15, F13); GLOSSOPLEURA (F9); ALBERTELLA (F)

MOUNT WHYTE FM 150'± — OLENELLUS (F20, F16)

JONAS CREEK FORMATION 3000'± — FAUNAL ZONES

HECTOR FORMATION 8000'±

LEGEND

LIMESTONE

CONGLOMERATE LENSES

FAUNAL ZONES

SHALY LIMESTONE

DOLOMITE

SANDSTONE, commonly Quartzitic

LIMESTONE & DOLOMITE with CHERT NODULES & LENSES

SHALE

CALCAREOUS SHALE

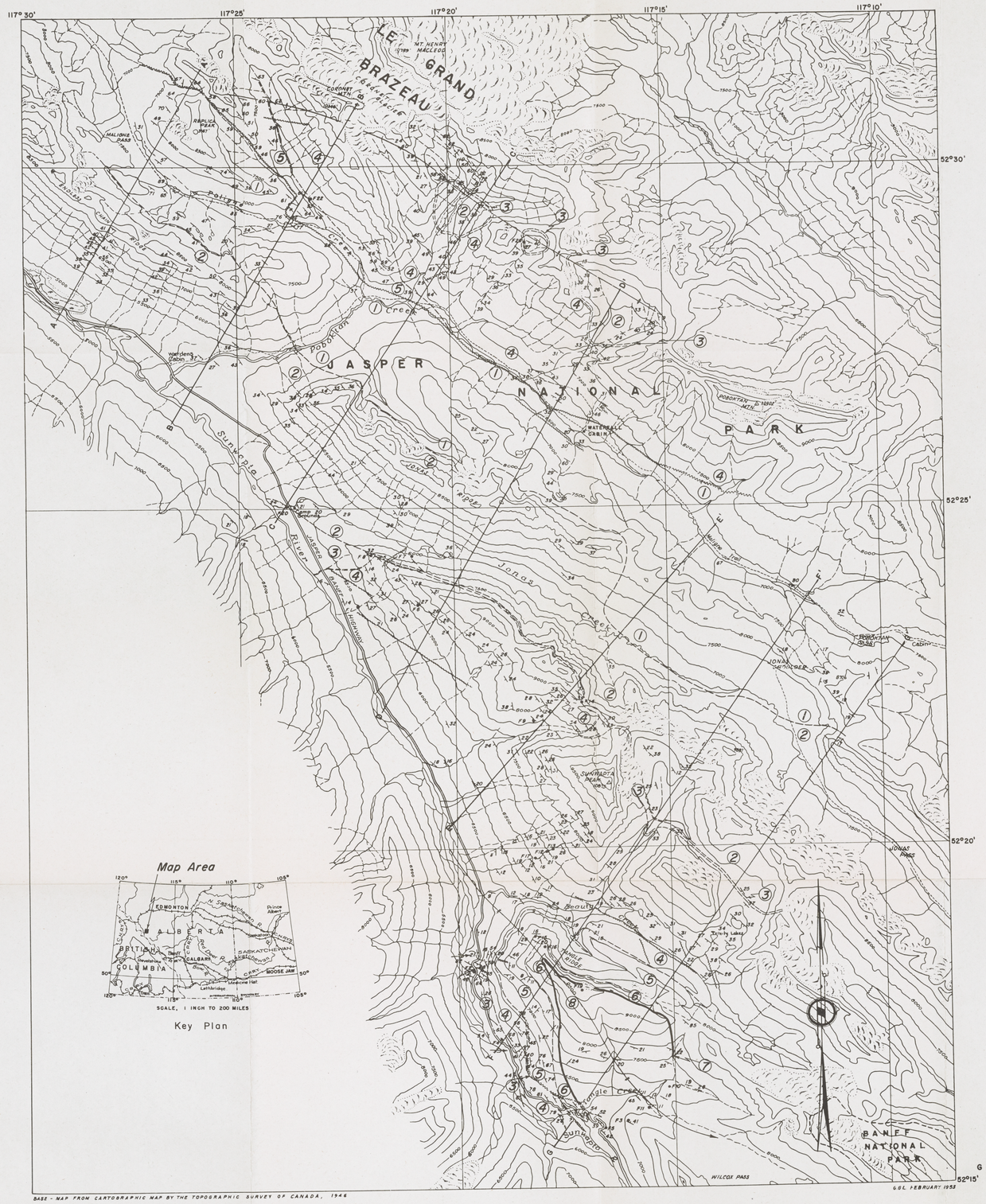
BASIC VOLCANIC ROCKS

VERTICAL SCALE

1 INCH TO 2000 FEET

GEOLOGY BY R. D. HUGHES 1951, AND 1952.

MAP TO ACCOMPANY THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE UNIVERSITY OF OKLAHOMA



Map Area

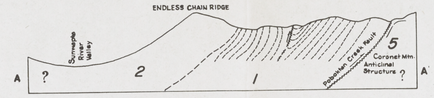
Key Plan

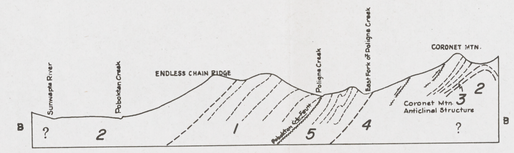
BASE - MAP FROM CARTOGRAPHIC MAP BY THE TOPOGRAPHIC SURVEY OF CANADA, 1946

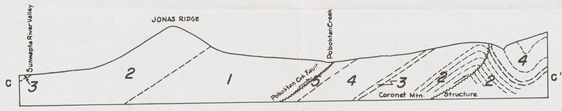
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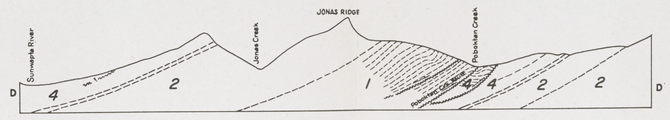
CONJECTURAL STRUCTURE SECTIONS

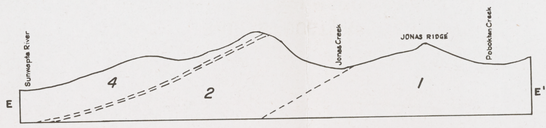
DATUM = 3000 FEET ABOVE SEA LEVEL

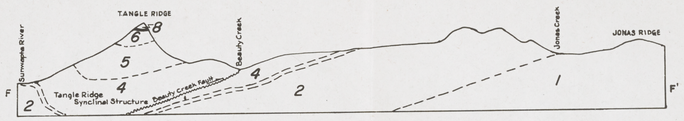


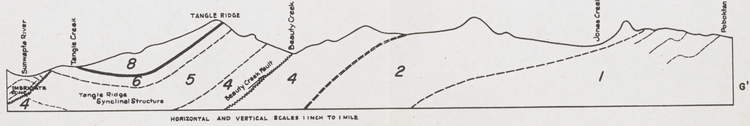












HORIZONTAL AND VERTICAL SCALES 1 INCH TO 1 MILE

GEOLOGICAL MAP OF PORTIONS OF SUNWAPTA AND SOUTHESK MAP-AREAS

ALBERTA CANADA

SCALE 63,360 OR 1 INCH TO 1 MILE

MILES 0 1 2 3

APPROXIMATE MAGNETIC DECLINATION 1953, 25°00' EAST

SHEET 2

PHOTOGEOLOGIC MAP SERIES

SHEET 3

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SCALE

1:126,720

One inch to two miles

2 0 2 4 6 miles

LEGEND

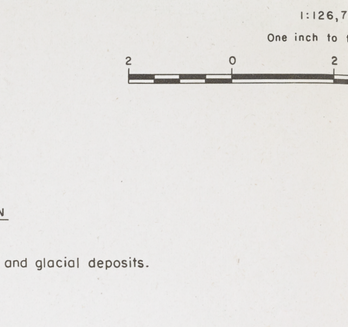
AGE	FORMATION	SYMBOL	DESCRIPTION
QUATERNARY		Q	Mainly recent alluvium and glacial deposits.
CARBONIFEROUS	Rundle, Banff, Exshaw	C	Carboniferous rocks undivided
DEVONIAN	Palliser, Alexo, Fairholme	D	Devonian rocks undivided
ORDOVICIAN	Mt. Wilson, Sarbach, Mons (Applicable in Mt. Wilson area)	O	Ordovician rocks undivided
CAMBRIAN		€	Cambrian rocks undivided
PROTEROZOIC		p€	Proterozoic rocks undivided
		pD	Pre-Devonian rocks undivided

GEOLOGIC SYMBOLS

- Bedding appears horizontal on photographs
- Dip group 1, 1° to 3°
- Dip group 2, 3° to 10°
- Dip group 3, 10° to 25°
- Dip group 4, 25° to 45°
- Dip group 5, 45° to nearly vertical
- Bedding appears vertical on photographs
- Bedding overturned
- Dip and strike. Amount of dip cannot be estimated on photographs
- Dip component
- 5° Field observed dip
- S Strike line of prominent ridge or bedding. Direction of dip cannot be determined on photographs
- PDS Possible dip slope
- f—u···f Fault, dotted where extended through Quaternary deposits.
- f——f Fault, position indefinite.
- f—?—?—f Fault, inferred
- f—▲—f Thrust fault, triangles on thrust sheet
- Anticline, arrow denotes plunge. Diamond denotes approximate position of apex
- Syncline, arrow denotes plunge. Break and cross bars denotes approximate position of high point.
- Anticline and syncline, position indefinite.
- Anticline and syncline, axis appears to coincide with fault trace.
- Contact, dashed where indefinite
- Contact, inferred

CULTURAL AND GEOGRAPHIC SYMBOLS

- Provincial highway
- Main road
- Secondary road
- Minor road or trail
- Railroad, single or double track
- Bridge, railroad
- Bridge, road
- National park and forest conservation area boundary
- Forestry cabin
- Forestry lookout tower
- Town, population 1 - 250
- Town, population 250 - 1000
- Building
- Group of buildings
- Streams
- Intermittent stream
- Lake or pond
- Icefield



This reconnaissance geologic map was prepared entirely from aerial photographs without benefit of field check and should not be construed as a final analysis. Positions of stratigraphic boundaries are based upon the limited stratigraphic information available at this time.

Roads not on aerial photographs were positioned from maps of the Alberta Planimetric Series.

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PLATE 10b